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March 2004
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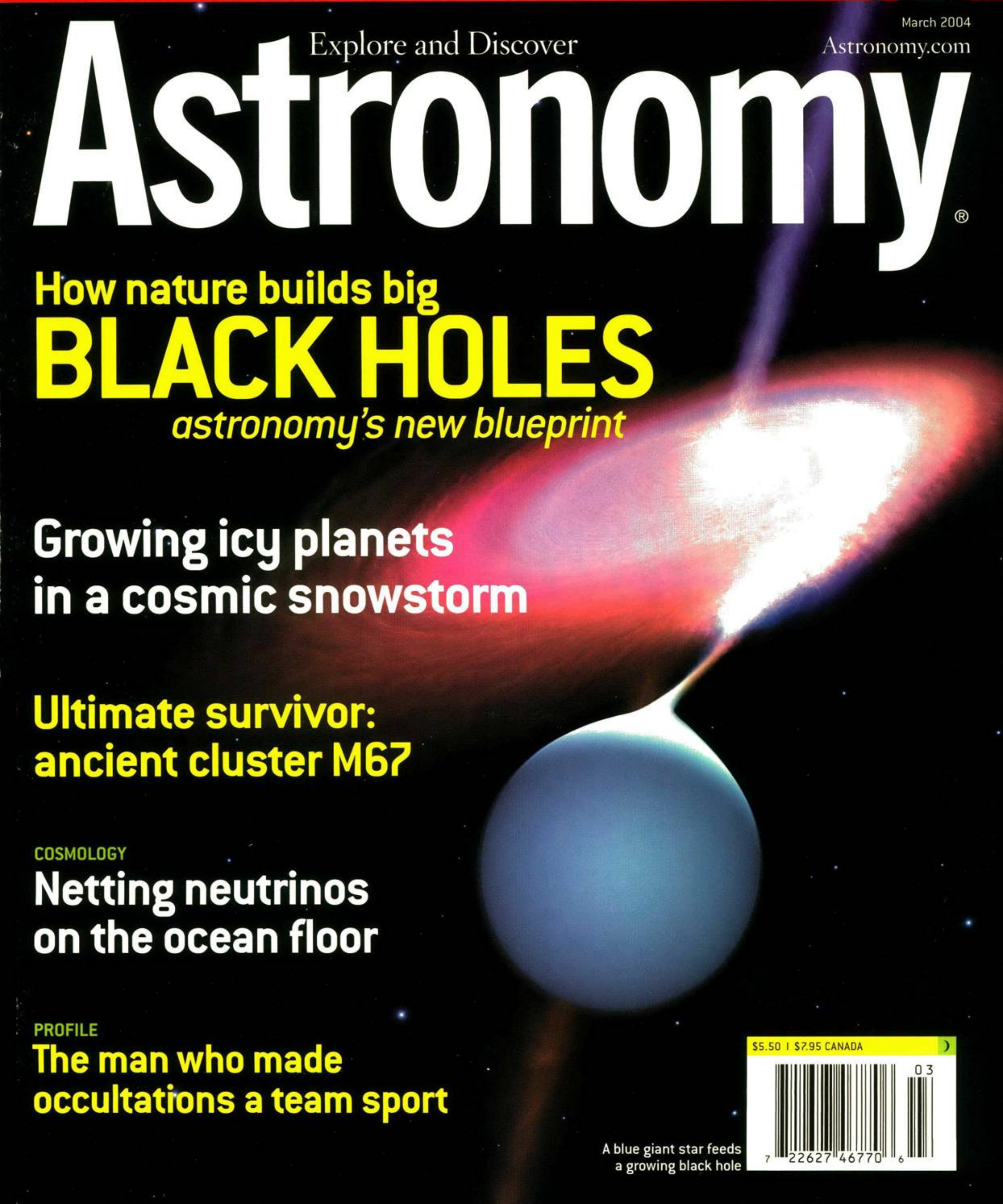

How nature builds big BLACK HOLES

astronomy's new blueprint

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Ultimate survivor: ancient cluster M67

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A blue giant star feeds
a growing black hole

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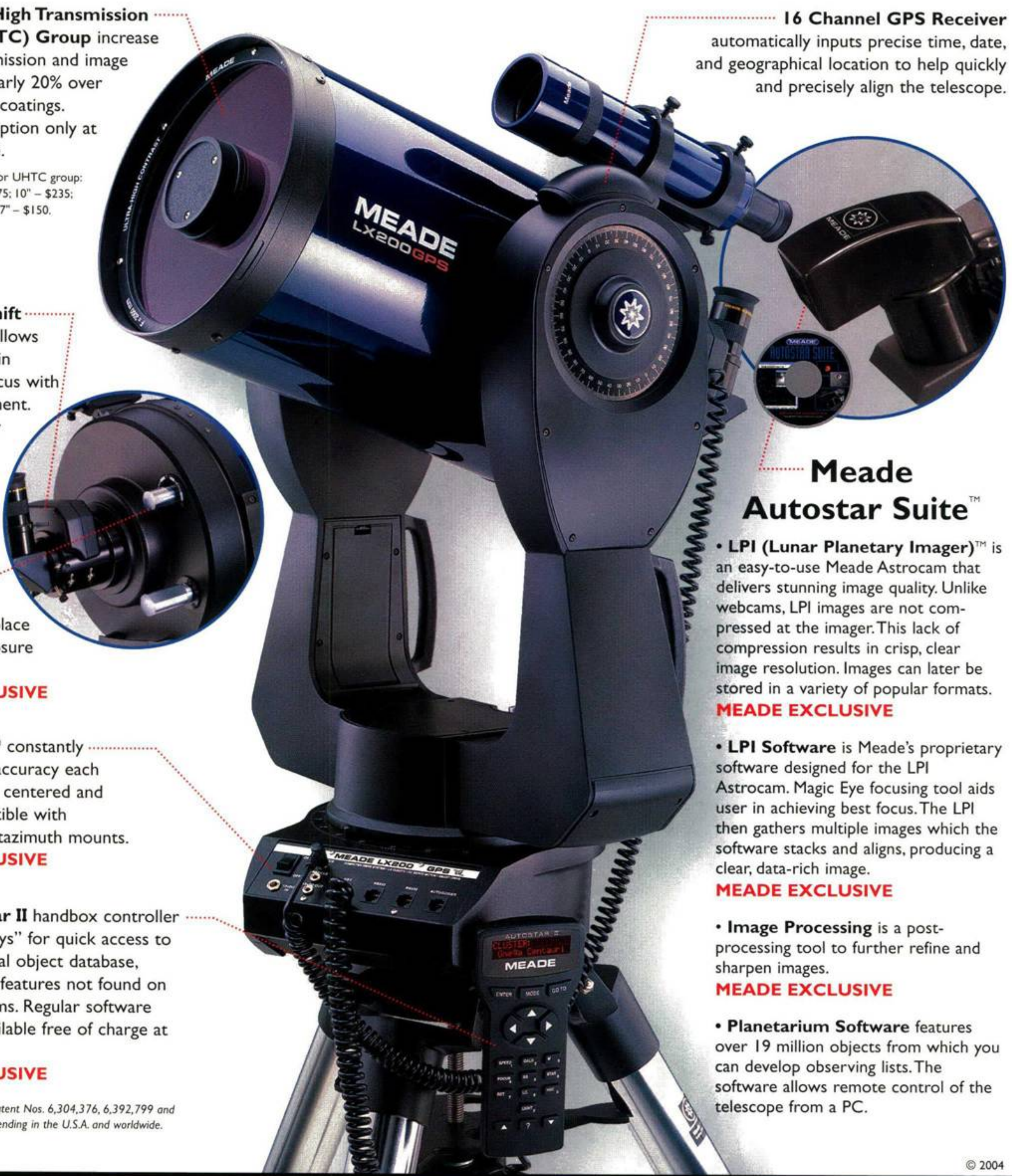
LX200GPS

OPTICAL & MECHANICAL EXCELLENCE



Meade Ultra-High Transmission Coatings (UHTC) Group increase total light transmission and image brightness by nearly 20% over Meade standard coatings. Available as an option only at time of purchase.

Add to telescope price for UHTC group: 8" LX200GPS-SMT – $175; 10" – $235; 12" – $295; 14" – $350; 7" – $150.

Zero Image-Shift Microfocuser allows the user to obtain precise image focus with no image movement. Operates at four different speeds from the Autostar II handbox.

Primary Mirror Lock locks mirror in place during long-exposure photography.
MEADE EXCLUSIVE

Smart Mount™ constantly refines pointing accuracy each time an object is centered and updated. Compatible with equatorial and altazimuth mounts.
MEADE EXCLUSIVE

Meade Autostar II handbox controller features "Hot Keys" for quick access to a 145,000 celestial object database, along with many features not found on competing systems. Regular software upgrades are available free of charge at *meade.com*.
MEADE EXCLUSIVE

Manufactured under U.S. Patent Nos. 6,304,376, 6,392,799 and 6,563,636; other patents pending in the U.S.A. and worldwide.

16 Channel GPS Receiver automatically inputs precise time, date, and geographical location to help quickly and precisely align the telescope.

Meade Autostar Suite™

- **LPI (Lunar Planetary Imager)**™ is an easy-to-use Meade Astrocam that delivers stunning image quality. Unlike webcams, LPI images are not compressed at the imager. This lack of compression results in crisp, clear image resolution. Images can later be stored in a variety of popular formats.
MEADE EXCLUSIVE
- **LPI Software** is Meade's proprietary software designed for the LPI Astrocam. Magic Eye focusing tool aids user in achieving best focus. The LPI then gathers multiple images which the software stacks and aligns, producing a clear, data-rich image.
MEADE EXCLUSIVE
- **Image Processing** is a post-processing tool to further refine and sharpen images.
MEADE EXCLUSIVE
- **Planetarium Software** features over 19 million objects from which you can develop observing lists. The software allows remote control of the telescope from a PC.

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meade.com

Suggested U.S. national mail-order retail prices for LX200GPS-SMT models:
7" – $2695; 8" – $2195; 10" – $2745; 12" – $3595; 14" – $4995

Packing & shipping charges in the 48 states:
8" LX200GPS-SMT – $105; 10" – $145; 12" – $215; 14" – $265; 7" – $125.

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RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or studying tenuous nebulosity in deep-space, Meade SP's deliver unmatched contrast and image sharpness. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal. **Super Plössls** (SP; 4-elements; 1.25"; 52°): **6.4, 9.7, 12.4, 15, 20, 26mm** each: **$79.95** (4.54); **32mm** (52°); **40mm** (44°) each: **99.95** (5.26); **56mm** (52°; 2") **199.95** (7.02)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above. **Super Wide Angle** (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™ Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians. **Ultra Wide Angle** (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

#1209 Zero Image-Shift Microfocuser

Identical to the Microfocuser supplied with Meade LX200GPS telescopes, but provided with a separate handbox for use with all other Meade SCT models (e.g. LX10, LX50, LX90, LX200) or for Schmidt-Cassegrains of other brands. Threads directly to the telescope's rear cell. Permits extremely precise focusing of the image during visual or photographic applications; during CCD applications maintains precise image centration on even the smallest CCD chips. Operates at four speeds, from extremely slow to fast; accepts both 2" and 1.25" eyepiece barrels. Requires 8 x AAA (user-supplied) batteries. **$249.95** (9.85)

CCD-Photo-Visual Flip-Mirror Systems

Use with ***any*** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XTE, ST-7, or AP1, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XTE, or ST-4 through ST-10; or AP2, AP7; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **$149.95** (5.26)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of longer focal-length Barlows. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm. **$79.95** (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models; ST-4 through ST-8; AP1, AP2; and others. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25". **$129.95** (4.54)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included. $99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue — each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

#911B
#908B
#911X
#908X

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia. **79.95** (4.54)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia. **89.95** (4.54)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **119.95** (5.26)

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

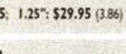
#908X–Threads into 1.25" eyepieces, 26mm dia. **99.95** (4.54)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes; 36mm dia. **149.95** (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-35mm camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; 1.25": $29.95 (3.86)

Variable Tele-Extender



For eyepiece-projection photography with any Meade or Celestron Schmidt-Cassegrain. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your 35mm camera.

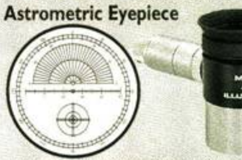
$39.95 (3.86)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25". **$149.95** (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **$129.95** (5.26)

MA12mm Illuminated Reticle Astrometric Eyepiece



A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25". **$119.95** (4.26)

Series 4000™ 8mm – 24mm Zoom Eyepiece

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25". **$219.95** (6.38)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography with 35mm cameras; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for Schmidt-Cassegrains

Rigidly couples 35mm camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

ANACORTES TELESCOPE, Anacortes, WA.
Orders & Information: 800-850-2001.

RIVERS CAMERA, Dover, NH.
Orders & Information: 800-245-7963.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 847-367-4600.

WOODLAND HILLS CAMERA & TELESCOPE, Woodland Hills, CA. Orders: 888-427-8766; Info.: 818-347-2270.

EFSTONSCIENCE, Toronto, Ontario, Canada
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KHAN SCOPE CENTRE, Toronto, Ontario, Canada
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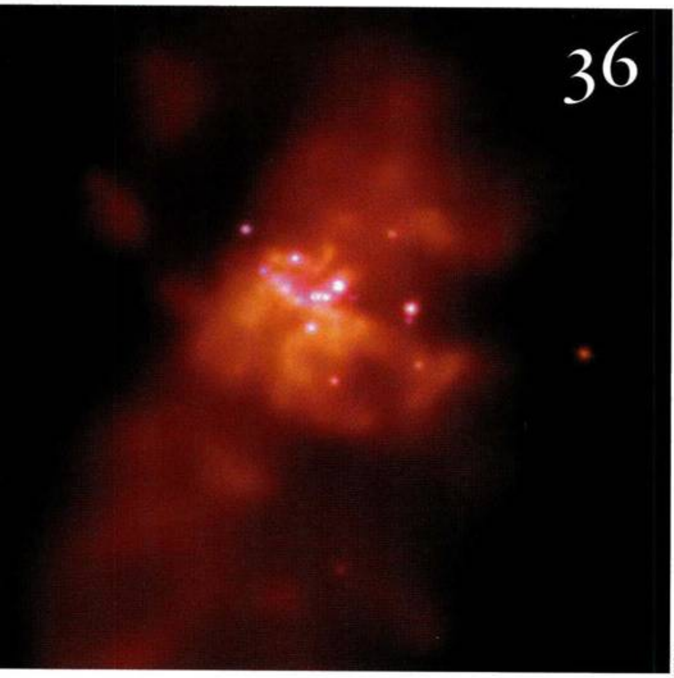
features



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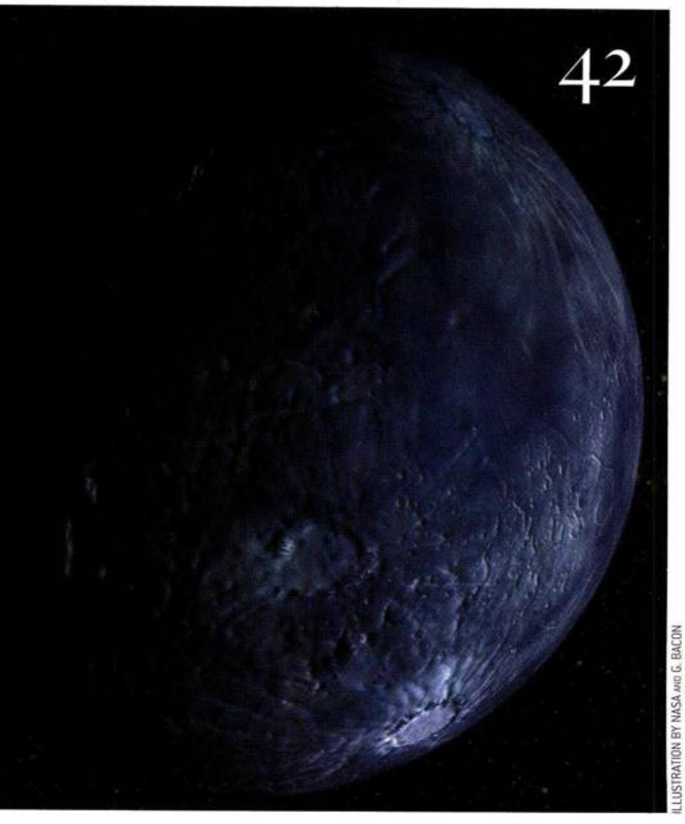

ILLUSTRATION BY NASA AND G. BACON

COVER STORY

36 Black holes in the middle

Supermassive black holes with masses greater than a million suns dwell in most large galaxies. While astronomers know how black holes the size of a single star form, how such behemoths form remains a mystery. STEVE NADIS

PLANETARY SCIENCE

42 Cosmic snowstorm

It takes a billion billion snowflakes to make a comet and a billion comets to make a planet the size of Pluto; learn how snowstorms in space formed the icy bodies at the far reaches of our solar system. SCOTT KENYON

COSMOLOGY

48 Into the abyss

From the depths of the Mediterranean Sea, a new observatory hopes to see the fleeting light emitted when a neutrino strikes an atom. Ubiquitous yet nearly impossible to catch, neutrinos pose a challenge for any detector but, if caught, promise to open a new window on the universe. BRUCE DORMINEY

GALACTIC ASTRONOMY

70 M67: the Ultimate Survivor

Talk about "survival of the fittest." While similar clusters have fallen prey to giant interstellar clouds, open star cluster M67 has a lifestyle and habitat that have kept it out of harm's way for nearly 5 billion years. KEN CROSWELL

CELESTIAL PORTRAITS

76 Cancer, Leo, and Leo Minor

The final installment of our constellation-by-constellation observing series features the deep-sky splendor of the Crab, the Lion, and the Little Lion. TOM POLAKIS

PROFILE

80 Disappearing act

Occultations are commonly predicted today, but that was not always the case. Meet David W. Dunham, the man responsible for the technique that enables people worldwide to observe these spectacular events. TRUDY E. BELL

ASTROPHOTOGRAPHY

84 Capturing aurorae

Skyshooting is easy when you follow these tips from an expert. See how you can capture auroral displays, one of nature's most beautiful phenomena, using only a camera and tripod. CORY LOEWEN

TELESCOPE REVIEW

90 TAL's 150K and 200K

TAL's new telescope models, the 150K and 200K, are ready-to-observe systems based on a seldom used optical design. Is one of these scopes right for you? PHIL HARRINGTON

DANIEL B. PHILLIPS

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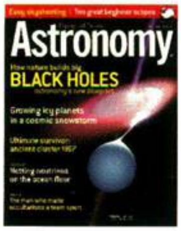

ON THE COVER

A blue supergiant star with the mass of about 30 suns finds itself drawn into a neighboring black hole with perhaps twice that mass. Theorists are excitedly exploring how encounters like this can build mid-size black holes that may merge and grow into supermassive ones. Observers, meanwhile, are beginning to pinpoint possible mid-size black holes in other galaxies. ARTWORK BY ADOLF SCHALLER

BY DAVID J. EICHER

The forgotten black holes

Ever since they were theorized in the 1700s, black holes have captivated the imagination of humankind. A region of space so massive and dense that nothing can escape its gravitational tug is a pretty weird thing. By the late 20th century, astronomers knew black holes were not only strange but real, too. They also described how black holes exist in two basic types: stellar-mass black holes created from dying stars, and supermassive black holes that power the central engines in active galaxies. Recently, however, evidence has come to light about a third class of black holes: intermediate-size ones. Science writer Steve Nadis's story "Black holes in the middle" (page 36) describes an alluring mystery and the detective work that is uncovering how these beasts fit into the framework of the universe.

Less massive, ordinary stars also have their place in the cosmos. Normally they are born in a cluster, separate as they orbit the center of a galaxy, and disperse into utter loneliness long before their old age. Astronomy popularizer Ken Croswell's story "M67: the Ultimate Survivor" (page 70), however, reveals the secret history of M67, an ancient cluster that has survived intact for nearly 5 billion years.

What has kept M67 together for so long, allowing the cluster to cheat death? The surprising answers lie entangled in chance and circumstance.

Stars don't hold a monopoly on the universe. At smaller scales, far from their parent suns, tiny snow showers flurry clumps of flakes together and build icy planets. Smithsonian Astrophysical Observatory astronomer Scott Kenyon's story "Cosmic snowstorm" (page 42) explains this dynamic process and how it has produced many of our neighbors in the nether regions of the solar system.

And stuff happens at really small scales, too. Deep under the Mediterranean Sea, a new telescope soon will be searching for the telltale signatures of neutrinos zipping through Earth. Science writer Bruce Dorminey's "Into the abyss" (page 48) tells the story of the ANTARES project, an ambitious European venture that could revolutionize the information gleaned from neutrino detections. These massless particles may tell us a lot about the Sun, supernovae, and gamma-ray bursts.

Be sure to check out "Ask Astro" on page 72. Readers tell us it's one of their favorite departments of our magazine. The question-and-answer service in which people submit queries about any part of the cosmos makes for a great read. Why is the Moon named *the Moon*? How do spiral galaxies spiral? Can light travel faster than we originally believed? No question is off limits in this factual free-for-all. Please e-mail your questions to askastro@astronomy.com or mail to 21027 Crossroads Circle, Waukesha, WI 53186.

As always, I invite you to contact me with comments. E-mail me at editor@astronomy.com. I will always be listening.

Yours truly,

Dave Eicher
Editor

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VoL. 32 No. 3

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The telescopes that have revolutionized amateur astronomy are now available with Autostar® and Field Tripod at very special low prices!

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GO TO

Meade ETX-125AT
Shown with standard-equipment #497 Autostar Controller and #884 Deluxe Field Tripod.

Matchless diffraction-limited optics: *Sky & Telescope* described ETX-90 optics as "excellent…stellar diffraction patterns were virtually textbook-perfect…the Cassini Division in Saturn's rings popped into view despite the rings' low tilt…Epsilon Lyrae's component stars were cleanly split…the Moon was beautiful at any magnification, with black shadows contrasting sharply with illuminated features along the terminator…the mechanics of the optical tube assembly are also first rate."

A long listing of standard-equipment features including rigid fork mounts; dual-axis drive systems with high-torque DC motors on both telescope axes; cordless field operation from eight (user-supplied) AA-batteries that power the telescope for more than 20 hours of normal usage; and internal flip-mirror system for observing or imaging from either the 90° or straight-through positions.

#497 Autostar Controller: The patented Meade Autostar controller brings automatic GO TO operation, plus dozens of additional menu options, to your fingertips, with a database of more than 30,000 celestial objects, including 5,386 galaxies, nebulae and star clusters from the Index Catalog (IC); 7,840 objects from the New General Catalog (NGC); 110 Messier objects; the major planets from Mercury to Pluto; and more.

#884 Deluxe Field Tripod: Constructed of strong, lightweight steel, the full-length Meade #884 Deluxe Field Tripod provides a rigid mounting platform for virtually any ETX observing application. Tripod height is adjustable for seated or standing observing. Use in either equatorial or altazimuth orientations; a graduated scale permits precise polar alignment. For Autostar applications, or for terrestrial observing, the tripod locks to 90°.

Each supplied with #497 Autostar Controller and #884 Deluxe Field Tripod:

ETX-90AT Astro Telescope	**$595**
ETX-105AT Astro Telescope	**795**
ETX-125AT Astro Telescope	**995**

Ultra-High Transmission Coatings (UHTC) group increases image brightness by about 20%: ETX-90AT– $50; ETX-105AT– $75; ETX-125AT– $95

Alternately, for the beginning-to-intermediate observer, the ETX-70AT is supplied with #494 Autostar Controller and #882 Field Tripod:

ETX-70AT Astro Telescope	**299**

Packing & shipping (ETX, Autostar, & Tripod): ETX-90AT — $30; ETX-105AT — $35; ETX-125AT — $40; ETX-70AT — $20.

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This exciting new package includes the following features and more* for only **$149:**

LPI (Lunar Planetary Imager)

combines the power of an electronic astronomical imager/autoguider with the simplicity of a web cam.

- Achieve great results the first time out on the Moon, planets, brighter deep-sky objects and terrestrial targets.
- Easy to use with real-time display of object on PC screen. Just center, focus and shoot.
- Magic Eye software-assisted focusing.
- Automatic and manual exposure control from .001 to 15 seconds (up to 450x longer than web cams).
- Automatically takes multiple exposures.
- Automatically selects best images.
- Automatically aligns multiple images and combines them into one superior image.
- Works as an autoguider for long-exposure astro images.

Meade LPI imager mounted on LX200GPS telescope.

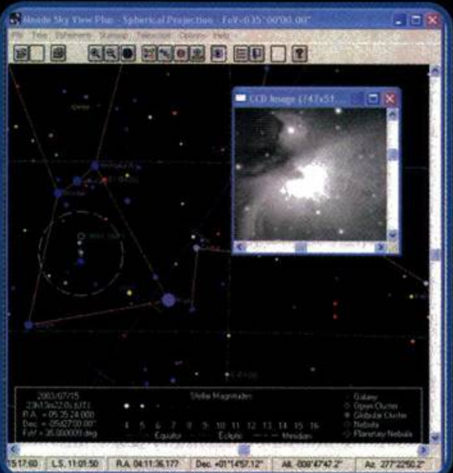
Autostar Suite Software

includes powerful tools to help you get the most from your Meade telescope.

- Sophisticated planetarium program with over 19 million objects.
- Select objects from the planetarium display and the telescope slews to those objects.
- Advanced Image Processing Software including Unsharp Masking, Convolution Filtering and many other features.
- Control all Autostar functions from a PC.
- Talking Telescope software translates Autostar text to synthesized speech through PC speaker.
- Point-and-click Autostar tour generation.
- Create observing lists and download to Autostar.
- Remote telescope control over the internet.
- Autostar Updater Tool keeps your Autostar current by downloading the latest Autostar system firmware updates; comet, asteroid and satellite data from the internet. *An exclusive Meade feature.*
- Includes cables to connect your Autostar-equipped telescope to your PC.

Meade Autostar Suite and LPI (Lunar Planetary Imager/Autoguider): For all Meade telescopes equipped with Autostar II and #497 Autostar Computer Controllers**, **complete with Autostar-PC interface cables – $149**

**For use with other Meade telescopes see the Meade web site.



Planetarium program showing Orion region.

Image of Saturn by Jeff Hobbs taken with an LPI connected to a 12" LX200GPS. The image is a composition of images automatically selected and registered by the Autostar Suite software.

Moon image taken with altazimuth mounted 8" LX90 by first-time user of the LPI imager and software.

***Visit the Meade web site at www.meade.com for complete description of features and detailed specifications.**

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MEADE 8" LX90

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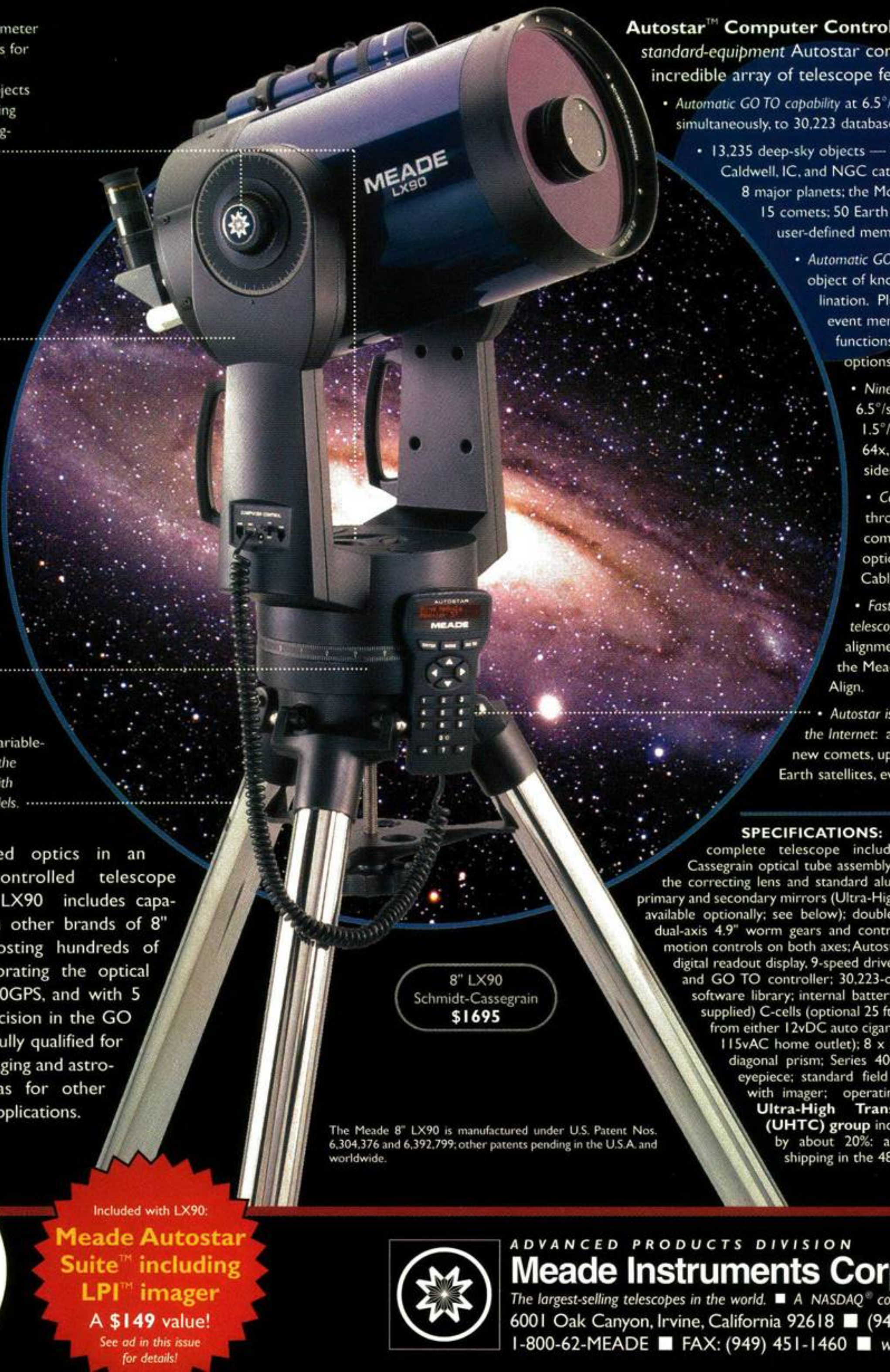

Worm gears of 4.9"-diameter on both telescope axes for smooth sidereal-rate tracking of celestial objects as well as precise guiding corrections during long-exposure imaging.

Die-cast-aluminum *double-tine* fork mount that rigidly supports the optical tube in all sky orientations.

The LX90 is powered for about 60 hours by 8 (user-supplied) C-cell batteries. Alternately, the telescope may be powered from an automobile cigarette lighter plug or from a standard 115vAC home outlet, using optionally available power cords.

Rigid chromed-steel variable-height field tripod — *the same tripod provided with Meade LX200GPS models.*

Autostar™ Computer Controller: The LX90's *standard-equipment* Autostar controller permits an incredible array of telescope features:

- *Automatic GO TO capability* at 6.5°/sec on both axes, simultaneously, to 30,223 database objects, including:
  - 13,235 deep-sky objects — the complete Messier, Caldwell, IC, and NGC catalogs; 16,888 stars; the 8 major planets; the Moon; 26 asteroids; 15 comets; 50 Earth satellites; plus 200 user-defined memory locations.
- *Automatic GO TO capability* to any object of known R.A. and Declination. Plus hundreds of special event menus, guided tours, utility functions, and telescope status options.
- *Nine selectable slew speeds:* 6.5°/sec, 3°/sec, and 1.5°/sec, as well as 128x, 64x, 16x, 8x, 2x, and 1x sidereal.
- *Control of the telescope* through your personal computer. (Requires optional #505 Connector Cable Set.)
- *Fast alignment of the telescope* using any of three alignment functions, including the Meade-proprietary Easy Align.
- *Autostar is fully upgradeable over the Internet:* add the positions of new comets, update the positions of Earth satellites, even add new software.

With diffraction-limited optics in an Autostar computer-controlled telescope system, the Meade 8" LX90 includes capabilities not available on other brands of 8" Schmidt-Cassegrains costing hundreds of dollars more. Incorporating the optical system of the 8" LX200GPS, and with 5 arc-minute pointing precision in the GO TO mode, the LX90 is fully qualified for long-exposure CCD imaging and astrophotography as well as for other advanced photo-visual applications.

8" LX90
Schmidt-Cassegrain
$1695

The Meade 8" LX90 is manufactured under U.S. Patent Nos. 6,304,376 and 6,392,799; other patents pending in the U.S.A. and worldwide.

SPECIFICATIONS: 8" LX90 — Each complete telescope includes 8" f/10 Schmidt-Cassegrain optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally; see below); double-tine fork mount with dual-axis 4.9" worm gears and control panel; electric slow-motion controls on both axes; Autostar hand controller with digital readout display, 9-speed drive controls on both axes, and GO TO controller; 30,223-object onboard celestial software library; internal battery port accepts 8 (user-supplied) C-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); 8 x 50mm viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm eyepiece; standard field tripod; Autostar Suite with imager; operating instructions. **$1695. Ultra-High Transmission Coatings (UHTC) group** increases image brightness by about 20%: add **$175.** Packing & shipping in the 48 states: $95.

SUPER PLÖSSL 40mm

Hurry! Offer ends 2/29/04.

Buy a $650 Super Plössl eyepiece set for your LX90 telescope for only $99!

Included with LX90:
Meade Autostar Suite™ including LPI™ imager
A **$149** value!
See ad in this issue for details!

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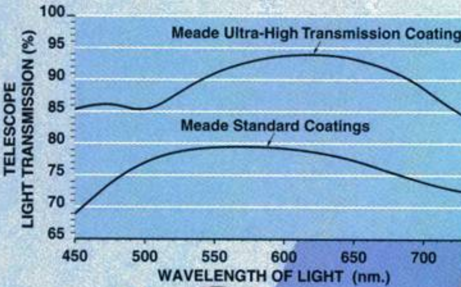
Choose from nine Meade Schmidt-Newtonians, Schmidt-Cassegrain, and Achromatic Refractors, each with Autostar® or Electronic Controller — from $579, *complete!*

Meade Ultra-High Transmission Coatings (UHTC) Group: Available optionally at the time of telescope purchase, the UHTC group increases image brightness by about 20% over the visible spectrum.



Observe ***hundreds*** of galaxies, nebulae, and star clusters of all types ***your very first night out,*** and hundreds more the next night out, simply by pressing the Autostar GO TO pushbutton. Watch as the telescope fast-slews at 4.5°/second, locating each object — from the brightest to the most obscure — and placing it automatically, unerringly, and precisely in the telescopic field. Or choose one of the new EC-models with dual-axis Electronic Controller, telescopes upgradable at any time in the future to full GO TO status just by adding the Autostar hand controller.

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Meade Model SC-8
8" f/10 Schmidt-Cassegrain Telescope with standard-equipment Autostar Control System.
Complete as shown: **$1195.**

Meade Model SN-8
8" f/4 Schmidt-Newtonian Telescope with standard-equipment Autostar Control System.
Complete as shown: **$839.**

Hurry! Offer ends 2/29/04.

Buy a $650 Super Plössl eyepiece set for your LXD55 telescope for only $99!

6", 8", and 10" LXD55-Series Schmidt-Newtonians with Autostar

Meade American-made diffraction-limited Schmidt-Newtonian optics yield pinpoint stellar images over extremely wide fields, with *one-half* the coma of paraboloids of the same focal ratios. Fast f/4 (8", 10") or f/5 (6") optics present brilliant, rich-field imaging of nebulae, galaxies, and star clusters. High-power lunar and planetary images reveal subtle detail often lost in telescopes of lesser resolution. The standard-equipment **Autostar Dual-Axis Control System** permits an amazing range of operations: *automatic GO TO capability* at 4.5°/second to 30,223 database objects (galaxies; diffuse and planetary nebulae; star clusters; the complete Messier, Caldwell, IC, and NGC catalogs; double and variable stars; eight major planets; asteroids; and comets); *nine selectable slew and slow-motion speeds* from 1x sidereal to 4.5°/sec.; plus *automatic sidereal-rate tracking* in RA, and much more.

SPECIFICATIONS: Models SN-6, SN-8, and SN-10 Schmidt-Newtonian Telescopes — Each complete telescope includes 6" f/5, 8" f/4, or 10" f/4 Schmidt-Newtonian optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally); white-enameled metal optical tube with machined-aluminum mirror cell; quick-release cradle ring assembly with locks; 6 x 30mm achromatic viewfinder; metal rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces; Series 4000 Super Plössl 26mm eyepiece. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12v DC auto cigarette lighter plug or from 115v AC home outlet); operating instructions.

6" Model SN-6 Schmidt-Newtonian	**$695**
8" Model SN-8 Schmidt-Newtonian	**839**
10" Model SN-10 Schmidt-Newtonian	**995**

Ultra-High Transmission Coatings (UHTC) group: 6" Model SN-6 – $85; 8" Model SN-8 – $125; 10" Model SN-10 – $150.

Packing & shipping charges in the 48 states: 6" – $75; 8" – $85; 10" – $95.

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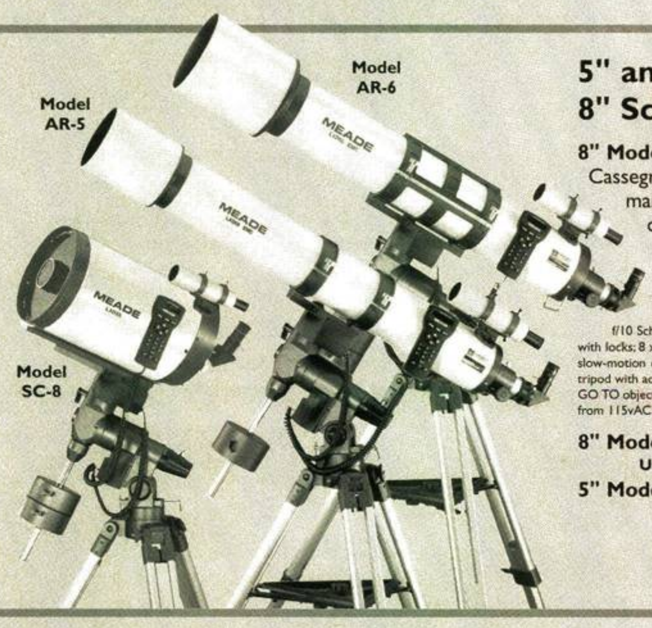
Model SN-6
6" Schmidt-Newtonian with Autostar

Model SN-8
8" Schmidt-Newtonian with Autostar

Model SN-10
10" Schmidt-Newtonian with Autostar



Model AR-6

Model AR-5

Model SC-8

5" and 6" LXD55-Series Achromatic Refractors and 8" Schmidt-Cassegrain with Autostar

8" Model SC-8: Includes the f/10 optical system of the Meade 8" LX200GPS for razor-sharp Schmidt-Cassegrain photo-visual imaging of the Moon, planets, and deep-space. All the telescope required by many amateurs for a lifetime of serious observing. **5" Model AR-5, 6" Model AR-6:** Excellent optical performance from the classical 2-element achromat design, with images rich in resolution and contrast and a minimum of chromatic aberration. Models SC-8, AR-5, and AR-6 allow for the full range of Autostar functions described above.

SPECIFICATIONS: Models SC-8 Schmidt-Cassegrain and AR-5 and AR-6 Achromatic Refractors — Each complete telescope includes 8" f/10 Schmidt-Cassegrain with MgF_2/standard coatings or 5" f/9 or 6" f/8 achromatic refractor with EMC super multi-coatings; quick-attach cradle ring assembly with locks; 8 x 50mm viewfinder; Series 4000 Super Plössl 26mm eyepiece; diagonal prism. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); operating instructions.

8" Model SC-8 Schmidt-Cassegrain	**$1195**
UHTC group for Model SC-8	$175
5" Model AR-5 Achromatic Refractor	**695**
6" Model AR-6 Achromatic Refractor	**895**

Packing & shipping charges in the 48 states: 8" – $85; 5" – $85; 6" – $95.

6" and 8" LXD55-Series Schmidt-Newtonians and 5" Achromatic Refractor with Electronic Controller

All the performance and features of the Autostar models above, but with 4-speed (2x, 8x, 32x, 4.5°/sec.) dual-axis Electronic Controller in place of Autostar. Upgrade to the Autostar Controller, available separately, at any time.

SPECIFICATIONS: Models SN-6EC, SN-8EC, and AR-5EC — Identical in every detail to the respective Models SN-6, SN-8, and AR-5, above, but with Electronic Controller (EC) in place of Autostar Hand Controller. Electronic Controller includes four dual-axis slewing speeds: 2x for photoguiding; 8x for image centering in the main telescope; 32x for image centering in the viewfinder; 4.5°/second for rapid-slew of the telescope across the sky; plus automatic sidereal-rate RA tracking. ***#497 Autostar Controller may be added at any time in the future and permits the full range of Autostar functions, including automatic GO TO, as described for Autostar-equipped telescopes, above.***

6" Model SN-6EC Schmidt-Newtonian	**$579**
8" Model SN-8EC Schmidt-Newtonian	**699**
5" Model AR-5EC Achromatic Refractor	**579**
#497 Autostar Controller, for any EC-model above	**149**

Ultra-High Transmission Coatings (UHTC) group: 6" Model SN-6EC – $85; 8" Model SN-8EC – $125.

Packing & shipping charges in the 48 states: 6" SN-6EC – $75; 8" SN-8EC – $85; 5" AR-5EC – $85. All prices shown in this ad are suggested U.S. national mail-order retail prices.

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Universal matters

"Absurd universe" (November 2003) is an affront to my father's title as an eminent astronomer of the 20th century. With a mind so brilliant, Fritz Zwicky revealed a genesis of astounding cosmological achievements that still illuminate the scientific world. ☾ He was a scientific prophet and the sacrificial lamb for the provincial judgment of his colleagues. His emendation of intellect was such apodictic truth, and his presages were of such advance, that the standard mind only could falter in their presence. But literary siege has failed to wound his accomplishments.

THE FORCE OF GRAVITY is not completely understood by physicists, but its effects are observed by astronomers. Here, the gravity of galaxy NGC 2207 (left) is ripping IC 2163 apart. NASA/HUBBLE HERITAGE TEAM

Today, evidence of dark matter heralds the accuracy of his prophecy made more than seventy years ago. This prediction was visionary, and it is now realized as stunning scientific verity, as truth.

This scientist, a man of letters and a philosopher, blended empirical imagination with perpetual understanding and transformed it to academic discipline. As his youngest daughter, having had great propinquity to his genius, I am his voice against any malevolence, as his voice has been silenced by debt of nature.

— **BARBARINA ZWICKY,** PASADENA, CALIFORNIA

I enjoyed reading Michael Turner's "Absurd universe" and Bob Berman's "Left in the dark" (November 2003), which describe current theories of dark matter and energy.

I was disappointed, however, that both articles fail to mention a leading contender to these theories: Modified Newtonian Dynamics (MOND). Created in 1983 by physicist Mordehai Milgrom, MOND proposes that the force of gravity between very large masses with very small accelerations (such as interactions between galaxies or clusters) is increased.

Unlike theories of dark matter and energy, MOND accurately predicted measurements made years after its inception. In my opinion, this makes MOND a much more elegant and plausible explanation for cosmological observations than the belief that our universe is 96 percent "dark."

— **DAVE FOX,** AUSTIN, TEXAS

Illuminating illustration

Thank you for the map of the Local Group in "Order out of chaos" (November 2003). It provided a sense of perspective about the intergalactic neighborhood that previous works along these lines have not managed.

— **DWIGHT WILLIAMS,** ORLEANS, ONTARIO

What *is* the speed of light?

In "No time to lose?" (December 2003), Bob Berman wrote that if you point a flashlight toward the sky, all the photons reach the edges of the universe in no time. If that's true, then why does it take time for light from other stars to reach Earth?

— **DREW DONDERO,** CEDARBURG, WISCONSIN

From our frame of reference, light certainly does require time to chug along across the universe. From the light's perspective, however, the trip across the cosmos takes no time at all. Any future astronaut who manages to travel at near-light speeds would experience the same thing. From her perspective, she would leave here and arrive at the Andromeda Galaxy before even a single second had passed on Earth. To those tracking her from Earth, however, the trip would last more than two million years. — **BOB BERMAN**

Postscript

Stan McKiernan of Vandalia, Missouri, made the knives shown on page 87 in "The lure of meteorites" (December 2003).

Corrections

In "Imaging with webcams" (December 2003), Ashley Roeckelein shot the three celestial images on page 94. Jim Thommes imaged the Horsehead Nebula on page 95; see more at home.nethere.net/jthommes.

We welcome your comments. Send letters to Astronomy Letters, P.O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.

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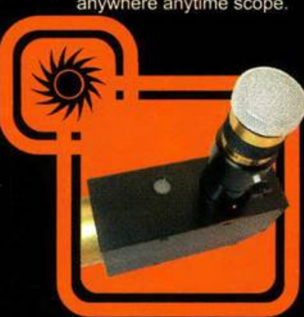

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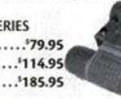

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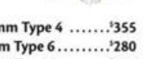

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A *SLOOH* of fun

In the "great idea" department, how's this? You fork over $49 a year for time at an exquisite mountaintop observatory with all the bells and whistles you could ever want: the best CCD cameras, filters, the works. Commanding this observatory with your computer from thousands of miles away, high-quality deep-space images appear on your monitor in glorious color, and *you* get to decide between keeping these magnificent celestial images for yourself or sharing them with friends.

Back in 2000, after Mike Paolucci had already made himself richer than an Enron CEO by selling his Internet company, he wondered how to make astronomy available to observers living in cities so light-polluted they have trouble locating the Moon. He acquired a location in the Canary Islands, spent a fortune on the best automated equipment, and scheduled the launch of a web site, *www.slooh.com*, for December 2003.

> So now you can lounge comfortably indoors, drink your latté, and view spectacular real-time space images.

How do I know this? Paolucci asked me to compile a list of the twenty best sky wonders and to write the material that subscribers will see — and hear — when they log on and join a "group mission." You see, as the project developed, Mike and his techno-geek friends found it super-difficult to let individual members actually point the scope anywhere they wanted. So, he decided to inaugurate the service with group missions, where subscribers all simultaneously observe the same target in real time.

When you join one of the observations-in-progress, you can click on any of the on-screen buttons to learn about the targeted object's history, mythology, and so on, from one of several characters who speak to you. Originally, Paolucci wanted this information to be recited by none other than Edwin Hubble, but people who knew Hubble described him as arrogant and unpleasant. Instead, the info will be explained by kooky characters still being refined by a TV production expert as I write this. I don't know if these performers will turn out to be cartoon corny, show-biz glamorous, or planetarium perfect. I sort of want them to resemble the people we see around us at astro-club meetings — but without the misbuttoned shirts.

For me, the best part of the project was choosing the twenty astro-targets for the packaged, real-time missions. You actually can vote for the next round of targets at www.slooh.com. Paolucci named the project "SLOOH" because he thought it had a high-tech ring.

The plan calls for subscribers to be able to command the telescope privately and acquire images themselves. As of the time of print, only the group missions are online. The current destinations include Saturn, Jupiter, galaxies M31, NGC 4565, M51 and M82, clusters Omega Centauri and M13, and the Crab, Orion, Dumbbell, and Horsehead nebulae. Astrophotographer Matt Bendaniel has been the Chief Technology Officer, and this observatory's images are stunning. The Whirlpool Galaxy looks almost as gloriously detailed and colorful as pictures from the What's-his-name Space Telescope.

So, now you can sit at home and enjoy real-time images from space while sipping a latté. I used to be a snob about CCD images and thought the direct visual impression at the eyepiece carried an ineffable impact that just couldn't be electronically duplicated on a monitor. I still feel that way, but I have to admit that the image quality from this superb site with high-end equipment blows away many of our backyard views.

Recently, I found a box of drawings I'd made when I was 14. Sketched in detail through the eyepiece of my 60mm refractor was the crater Copernicus, with its terraced walls, as well as drawings of the curlicued surface details of Jupiter. I remember standing, ten years later, at my old RV-6 reflector with my beard covered with ice in the –13° Fahrenheit night while I stared at Saturn for three hours. I was rapturous (or maybe it was hypothermia) during those fleeting moments of steady air when the Cassini Division stood out so sharply you could drive a truck through it. And later, as a professional astronomer, I used a 40-inch telescope with a visual eyepiece stuck on for fun. It was glorious, of course, but bitterly cold!

So, maybe it's envy that makes it hard to accept beginners can now lounge comfortably indoors and observe the heavens. It's a great idea as far-fetched as string theory: astronomy from a chair, cozy and snug.

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BY GLENN CHAPLE

Observers get set

"Welcome to Zanysports TV. I'm Steve Spaceshot, and I'm covering the United States Messier Marathon. The competitor who views the most Messier objects during this grueling all-night event will be crowned champion. It's a clear, moonless night — ideal conditions for the competitors.

"The favorite this year is *Astronomy* writer Phil Harrington, a veteran Messier marathoner and author of several articles on the topic. His stiffest competition will be Glenn Chaple, another *Astronomy* writer and a first-time Messier marathoner. This should be a compelling matchup.

"Well, I see the official starter has raised her gun. She fires, and dozens of telescopes and binoculars aim skyward in unison. Wait a minute. Chaple just pushed Harrington's telescope away from its first target. Harrington responds by pulling a $450 high-tech eyepiece from Chaple's telescope and throwing it into some nearby shrubs! The refs are trying to separate the two. This could get ugly."

Okay, there's no official U.S. Messier Marathon. And I would never sabotage Phil Harrington's telescope (well, I might *accidentally* bump into it in the dark). Messier marathons, though, *are* the real deal. The first few, held in the 1970s, were friendly competitions between members of astronomy clubs in the United States. Now, clubs worldwide conduct such events. Before I explain what a Messier marathon entails, let's find out more about that famous astronomer — no, not Harrington — who started it all.

Charles Messier was a late 18th-century French astronomer who specialized in comets. In his day, comets were a favored sky object, bringing fame (and occasionally fortune) to anyone who discovered one. While pursuing comets, Messier often stumbled on hazy patches of light that turned out to be — hazy patches of light.

THE BEEHIVE CLUSTER (M44) is one of more than 100 objects you'll pass during your Messier marathon. NOAO/AURA/NSF

To avoid being distracted by these "fake comets," he cataloged them — more than one hundred in all. Among the "fuzzy patches" in the *Messier Catalog* are some of the brightest and finest star clusters, nebulae, and galaxies in the night sky. These are cosmic showpieces — like the Andromeda Galaxy (M31) and the Orion Nebula (M42) — that budding astronomers cut their observing teeth on. Viewing all the Messier objects is considered a rite of passage for the rookie astronomer.

Usually, the Sun hides many Messier objects from view. But during late March, "Old Sol" occupies a Messier-poor part of the sky, so Messier marathoners can take to the streets — er, sky. The magic date this year is March 21.

Because this is a column for beginners, let's start out with a Messier mini-marathon. The all-sky map on page 59 shows the location of some of the brighter Messier objects. Let's try the following:

M45 (the Pleiades): It's hard to believe this bright naked-eye cluster could be mistaken for a comet.

M42 and **M43:** M42, the Orion Nebula, is easy to find with binoculars, but you'll need a telescope to pick out M43.

M35, M36, M37, and **M38:** These four clusters, visible with binoculars, are aligned in a row beginning at the foot of Gemini and continuing into the heart of Auriga.

M41: Scan the area a few degrees below Sirius to pick up this cluster.

M44: The Beehive Cluster is visible to the naked eye as a misty patch of light midway between Regulus in Leo and the twin stars Pollux and Castor, in Gemini.

M51: Bright as far as galaxies go, M51 is still faint for standard binoculars. Sweep the area near Eta (η) Ursae Majoris — the end star on the handle of the Big Dipper — with a telescope. Use low power.

M81 and **M82:** Like M51, these Messier galaxies are best found with a telescope and a low-power eyepiece. M81 has an oval form while M82 appears cigar-shaped, hence its nickname, the Cigar Galaxy.

To help train for your first Messier marathon, check out *www.messiermarathon.com*. Include Phil Harrington's article "Ready, Set, Go" (*Astronomy*, March 2002) as part of your regimen, as well.

And Phil, I'm calling you out. March 21, 2004. Sundown. A full Messier marathon. Keep your hands off my eyepiece!

There's a second mini-marathon we can enjoy this month — without optical aid. During the last week of March, Mercury, Venus, Mars, Jupiter, and Saturn will be strewn across the ecliptic after sunset.

Next month: We check out the constellation Leo and its telescopic treasures. Clear skies.

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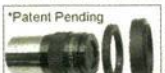
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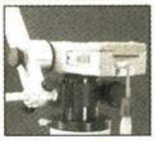

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STBOXS	Small (1-1/4" filter size box)............	**1.95**
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Color Filter Set For 1.25" Eyepieces

$37.95

4 piece set Includes Red #23A Yellow #12 Blue #80A Green #58A

Parfocal Rings

Make your EP's parfocal!

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STPBN5 NexStar 5.......	**59.95**

1.25" Extension

STEPEXT
12.95

Extends 1.25" EP barrel by 1 inch. Threaded for filters or stacking.

ScopeTronix Tripod Adapter & Accessory Holder for ETX

ETX Deluxe

Deluxe Tripod Adapter
Fits ¼" & 3/8" tripods. Holds Autostar & 4 Eyepieces. **STDXTRAD 96.95**

Accessory Tray for ETX

STTRAY90	ETX90....	**59.95**
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STTRAY125	ETX125..	**64.95**

Accessory Tray mounted to ETX

ScopeTronix Flexi-Focus™ for ETX Telescopes

Oversized knob and flexible shaft allow crisp, sharp focusing even when OTA is pointed straight up!

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Flexible shaft reduces vibrations Achieve sharp focus fast!

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5mw *continuous mode* laser beam is easily visible at night! 2 AAA batteries included.

STGREEN 5mw Green Laser Pointer **$189.00**

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These quality tripod bags are custom designed for the Meade field tripod used with the LX series scopes up to 10" such as the LX10/50/90/200/GPS. They are color keyed to match the Meade soft case. Features include full interior padding, heavy duty carry handles, an adjustable shoulder strap, and an outside pocket sized just right for a set of vibration suppression pads! **STBAGLX** LX tripod bag... **79.00**

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TVZN36........... 380.00

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SkyQuest XT10
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Special Offer!
Order now and receive a FREE TrueTrack™ single-axis drive or save $70 off a TrueTrack™ dual-axis drive.

SkyView Pro 6LT
For anyone interested in extra magnifying *power for viewing lunar terrain,* Jupiter's bands, Saturn's rings, or double stars, the 6LT will get the job done. The 150mm, 1200mm focal length (f/8) parabolic primary mirror delivers 60% greater magnification than you get from shorter models using the same eyepiece. Includes 6x30 finder scope, two 1.25" Sirius Plössl eyepieces (25mm and 10mm), collimation cap and dust-cap.

SVP 6LT & FREE drive
$469

SkyView Pro 8
Finally, a telescope that gives views that will blow you away without blowing your budget! A full 8" (203mm, f/4.9) parabolic primary mirror, which gathers 73% more light than a 6". The tube features a 2" aluminum rack-and-pinion focuser and a sturdy 4-vane holder. Includes 6x30 finder scope, two 1.25" Sirius Plössl eyepieces (25mm and 10mm), collimation cap and dust-cap.

SVP 8 & FREE drive
$549

SkyView Pro 120
Love refractors? We've combined our 120mm achromatic refractor with our super-sturdy SkyView Pro mount. The big fully multi-coated 120mm (f/8.3) objective lens and 2" focuser will give you jaw-dropping views of the skies. Includes 6x30 finder scope, two 1.25" Sirius Plössl eyepieces (25mm and 10mm), 90° star diagonal, collimation tool and dust-cap.

SVP 120 & FREE drive
$549

SkyView Pro 127
Given the popularity of our 127mm Mak, it's only natural that we offer it with the best new mid-sized equatorial mount in the market, the SkyView Pro. The 5" Maksutov-Cassegrain optics pull in plenty of light for great views of deep-sky gems. And you can't beat its long focal length of 1540mm (f/12.1) for high-magnification study of the Moon and planets. Includes 6x30 finder scope, two 1.25" Sirius Plössl eyepieces, (25mm and 10mm), 90° mirror star diagonal, optical tube carry case and dust-cap.

SVP 127 & FREE drive **$649**

Orion SkyView™ Pro 80mm ED EQ Apochromatic Refractor

New!

The SkyView Pro 80ED combines the best value in high-end refractors today with the stability and precision of our SkyView Pro equatorial mount - for a very attractive price.

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The SVP ED80 includes a 2" Crayford-type focuser with 2" or 1.25" eyepieces, two 1.25" Sirius Plössl eyepieces (25mm and 10mm), and 6x30 finder scope. Assembled weight, 38.8 lbs.

SVP 80ED & FREE TrueTrack™ Single-Axis Drive **$819**

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32mm, 40mm

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1.25" V-Block Filter

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1.25"

6.3mm, 7.5mm, 10mm, 12.5mm, 17mm, 20mm, and 26mm

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32mm, 40mm

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Our right angle finder scopes let you view in contortion-free comfort! What's more, they have built-in Amici prisms to provide correctly oriented, not upside down, views. Available in two sizes. Each comes with dovetail bracket.

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Shorty™ 2x Barlow Lens

This compact barlow is just 2-7/8" long, about half the length of a regular barlow, for greater convenience and versatility. Fits all 1.25" telescope eyepieces. Features a multi-coated, baffled achromatic lens system.

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LaserMate Collimator Was $64.95, **NOW $55.20**

LaserMate Deluxe Collimator Was $79.95, **NOW $67.95**

Orion Full-Aperture Glass Solar Filters

These filters deliver superb views of the Sun without risk to your eyes. The glass-elements are machine-polished and triple-coated for a scratch-resistant surface. Multiple sizes to fit telescopes with front diameters from 3.5" up to 12".

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This light-pollution filter blocks the most common wavelengths of urban and suburban sky glow for enhanced contrast and improved deep-sky views. SkyGlow filters are great for use in areas of moderate light pollution to provide high-contrast views of nebulas, galaxies and star cluster.

SkyGlow Broadband Filter

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For SC Scopes	Was $79.95, **NOW $59.95**

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Our ED-2 eyepieces are made of "Extra-low Dispersion" optical glass that boasts superior refractive properties. Epic 1.25" eyepieces feature a six-element lens design in which two of the elements are crafted from ED glass. Each provides luxurious 20mm eye relief, reduced chromatic aberration and a wide 55-degree apparent field

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Astronomy magazine

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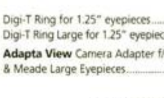

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news 03

Read all about it: a new way to find planets easily and cheaply, dust devils on Mars, sculpting planetary nebulae, galactic winds, and probing stellar cocoons.

HUBBLE HERITAGE IMAGE

Hubble sees starfire in the nearby Pinwheel Galaxy

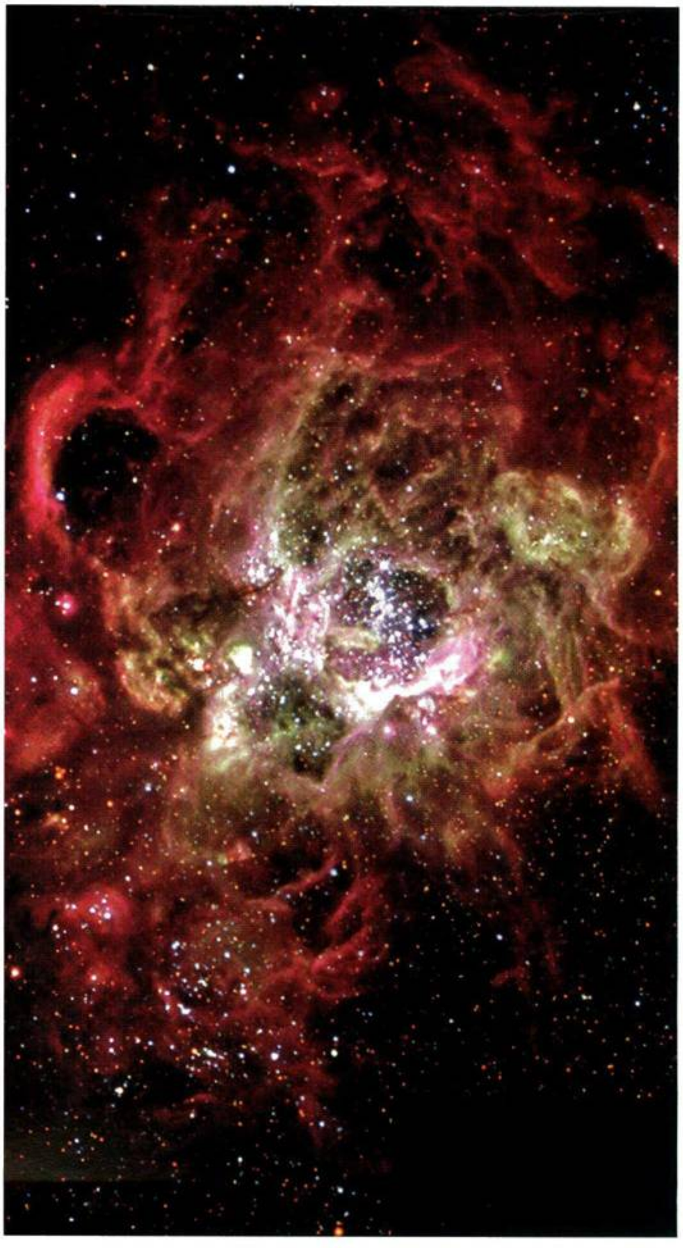
In the constellation Triangulum the Triangle, a spiral galaxy known as the Pinwheel (M33) harbors an enormous region of star formation within one of its arms. A giant cloud of mostly hydrogen gas 1,300 light-years in diameter, NGC 604 contains more than 200 brilliant, young, blue stars. It is one of the largest star-forming regions known — second only to 30 Doradus (the Tarantula Nebula) in the Large Magellanic Cloud, a satellite galaxy of the Milky Way.

In early December, the Hubble Heritage Team presented a dazzling new picture of this amazing region. The view is a composite of images taken during the past decade by various teams of scientists using Hubble's Wide Field Planetary Camera 2.

NGC 604 is similar to the better-known Orion Nebula — which is only one percent its size, however, and contains just four bright central stars, whereas NGC 604 holds nearly 200. Supernova explosions and intense stellar winds have stripped the center of NGC 604 of gas, so the cluster sits within relatively empty space.

NGC 604's stars are very hot and young — only 3 million years old. Its most massive star has more than 120 times the mass of the Sun. In this Hubble image, the gas surrounding the cluster is fluorescing because of the stars' strong ultraviolet radiation.

— MICHAEL E. BAKICH



NEW STARS BLAZE within NGC 604, a large, rich, star-forming region within the Pinwheel Galaxy (M33) in Triangulum. STScI AND HUBBLE HERITAGE TEAM

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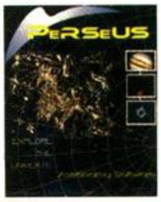

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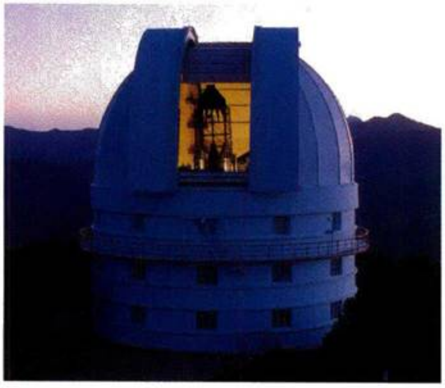
EXTRASOLAR PLANETS

Finding small ones

Astronomers at the University of Texas at Austin have devised a new way to find small exoplanets cheaply and quickly.

Still, there's a catch. The team can hunt planets only around white dwarfs, the superdense remnants of Sun-like stars that have passed through their red giant stage. A third of all white dwarfs show clocklike brightness pulses, the key ingredient for the new method. Planets beyond Earth's distance from the star should survive the red giant phase and be detectable, says team member Fergal Mullally, who has started observing 22 white dwarfs.



PULSES OF LIGHT from white dwarf stars are the key to finding small exoplanets, according to astronomers testing a new method with the 82-inch scope at McDonald Observatory. MCDONALD OBS.

Most exoplanets now are found via spectroscopic changes caused by a planet's gravity tugging on a star. Mullally's group, led by astrophysicist Don Winget, measures much larger changes in the time light pulses take to reach Earth as a star and planet orbit their shared center of gravity.

While the spectroscopic method excels at detecting massive planets very close to stars, the timing method trumps it for lighter planets in orbits twice the size of Earth's or larger, and it requires only a relatively small telescope.

"Detecting Jupiter at Jupiter's distance is duck soup," says Winget, "and we can push the [planets'] masses very, very low on a larger telescope." — **ROBERT ADLER**

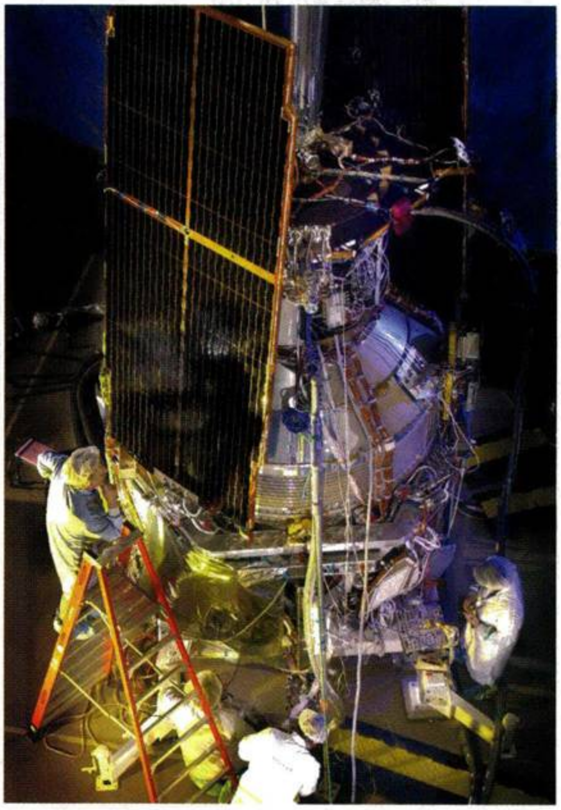
Probing relativity from Earth orbit

Almost half a century in the making, the Gravity Probe B space mission got within a month of launch late in 2003, only to be delayed again for repairs to its supersensitive navigation system. When launched, the mission will measure not stars or planets or even radiation, but the very fabric of space-time.

Developed by NASA and Stanford University, the mission uses supercooled gyroscopes to test two unverified predictions of Einstein's general theory of relativity. These involve how space and time are warped by the presence of Earth, and how Earth's rotation drags space-time with it.

The effects are tiny and require extreme sensitivity because near Earth they are so weak. But if verified (or more exciting, if *not* verified), the effects will have big implications for our knowledge of the nature of matter and the structure of the universe.

The idea is hardly new. Using a space gyroscope for this purpose was first proposed in 1959. In 1971, NASA began engineering studies of the technology. The precision needed was so far beyond what was then achievable that decades were spent building and testing prototypes (including a suborbital Gravity Probe A mission in 1976).



SUPERCOOLED GYROSCOPES lie at the heart of the Gravity Probe B mission. They will measure extremely delicate changes in space-time as a test of general relativity. STANFORD UNIV.

Developing a reference platform against which relativistic drift could be detected was literally an astronomical challenge. It wasn't enough to select any old guide star for the craft's star-tracker to observe. The problem was that astronomers didn't know the position of *any* star to the accuracy needed to differentiate a true signal from noise.

From its polar orbit, Gravity Probe B will lock on to the star IM Pegasi, which is barely visible to the naked eye. But IM Peg emits strongly at microwave frequencies. This lets project scientists use very-long-baseline interferometry to plot the star's position relative to background quasars. These lie far enough away to serve as benchmarks. Analysis of the observations will permit astronomers to determine the star's motion in the sky to an accuracy of about 0.1 milliarcsecond per year.

Comparing IM Peg's position to the rate of change of the gyros' spin directions will let project scientists test general relativity's effects with respect to the distant universe. — **JAMES OBERG**

MINOR PLANET 4 VESTA shows water-altered minerals on its surface, says an international team of planetary scientists. The water didn't come from inside Vesta, however – it arrived through impacts of meteorites.

PLANETARY NEBULAE

Do jets carve nebulae?

For the first time, astronomers have caught a red giant star in the earliest moments of becoming a planetary nebula. The red giant is believed to be part of a binary star system, and a jet from its unseen companion is shooting into the red giant's spherical debris cloud and shaping it.

"What we don't know," says astronomer Raghvendra Sahai of NASA's Jet Propulsion Laboratory, "is why these clouds have such intricate, complex shapes."

Reporting in the November 20, 2003, *Nature*, a team led by Sahai studied a red giant called V Hydrae, about 1,500 light-years away. Sahai theorizes jets and blobs of material coming from V Hydrae's more massive companion star are cutting intricate, symmetrical patterns into the sphere of gas and dust shed during V Hydrae's red-giant phase.

But, according to Sahai, for the jets and blobs to carve the red giant's gassy bubble requires a dense equatorial disk girdling the unseen star with the jets. In fact, observers had earlier found such an accretion disk around V Hydrae using the Owens Valley Radio Observatory Millimeter Array.

Team member Mark Morris (UCLA) is eager to test the model if and when V Hydrae blasts out more blobs. "We'll be lying in wait with the Hubble Space Telescope over the next several years," he says. — **R. A.**

THE OWL NEBULA got its nickname from the two large "eyes." These may be where jets from an unseen companion star have hollowed out the gas cloud from the inside. NOAO/AURA/NSF

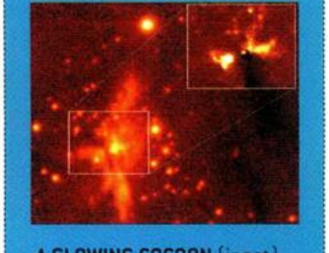
STAR FORMATION

Hot stellar cocoon

A giant envelope or disk of hot hydrogen gas has been found surrounding a massive young star about 20,000 light-years from Earth. It is the first time astronomers have seen such a disk emitting its own light.

A team led by Nanda Kumar (University of Porto, Portugal) found that, unlike most disks that are seen in silhouette, shock waves of unknown origin heated this one enough to glow.

"It tells us that massive stars form with different compositions and conditions than Sun-like stars," says Kumar. He also notes the disk is too hot to form planets. — ROBERT BURNHAM



A GLOWING COCOON (inset) surrounds a massive, young star. NANDA KUMAR/CAUP

PLANETARY SCIENCE

Kicking the Kuiper Belt

The Kuiper Belt, lying outward of Neptune's orbit, probably formed nearer the Sun, say scientists Hal Levison (Southwest Research Institute) and Alessandro Morbidelli (Observatoire de la Côte d'Azur), writing in *Nature* (November 27, 2003).

Their computer simulations suggest the belt, now located from 30 to 50 astronomical units from the Sun, formed near Neptune when it lay at about 20 AU. The belt later migrated with Neptune as it moved out to its current 30 AU.

This could explain the belt's sparseness (only a tenth of Earth's mass in all), and why some belt members have irregular orbits.

As Neptune grew, they say, its gravity perturbed nearby objects. As the planet drifted outward during formation, its perturbations moved also. These thinned the proto-Kuiper Belt, driving some members into irregular orbits while leaving others alone. — **R. B.**

OTHER SOLAR SYSTEMS

Vega's dusty disk hides a planet

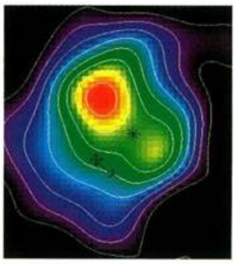
Bright clumps in the dusty disk around the nearby star Vega imply that a Neptune-size planet is circling the star in a Neptune-size orbit. If confirmed, then Vega would have a planetary system more like our own than any other of the 100-plus discovered to date.

Astronomer Mark Wyatt (Royal Observatory, Edinburgh) modeled what would happen to Vega's disk if a planet spiraled outward through it.

Wyatt's model explains the two bright clumps seen as the red and yellow spots in the image. The clumps are planetesimals corralled by a migrating planet. The dusty disk is debris shed by collisions among them.

Theorists think Neptune took a similar trip as it formed, scattering small planetesimals Sunward.

The model predicts the planet is moving from 40 to 65 AU from Vega, taking about 56 million years. "After a gap of a few years," says Wyatt, "we should see movement of the clumps." — **R. A.**

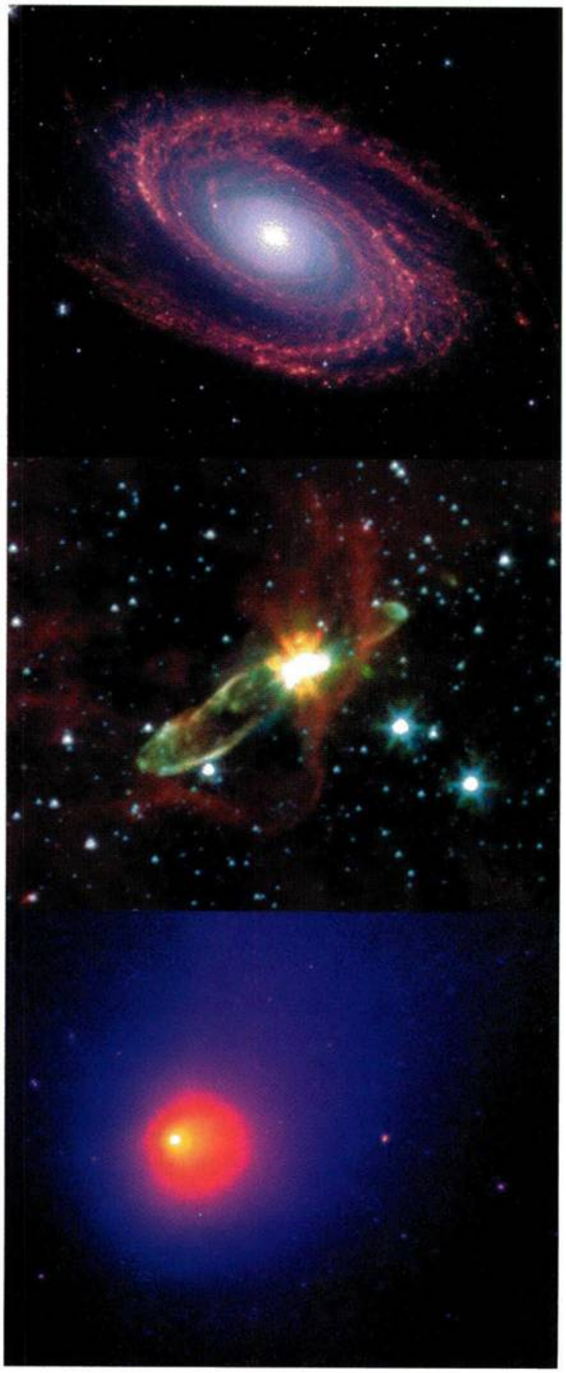


A DUSTY DISK around Vega (asterisk) contains a planet (diamond) orbiting as shown. PPARC

THE QUADRANTID METEORS, which peak early each January, have their source in the asteroidal object 2003 EH1. Its orbit closely resembles the Quadrantids's, and scientists suspect 2003 EH1 is an extinct comet nucleus.

SPITZER SPACE TELESCOPE

First (infrared) light



THE INFRARED UNIVERSE appears in these "first light" images from the Spitzer Space Telescope (formerly SIRTF), the last of NASA's Great Observatories. Top to bottom, we see galaxy M81 (with regions of red, ionized hydrogen); a young star, Herbig-Haro 46, swaddled in cocoons of dust and water vapor; and an active comet, Schwassmann-Wachmann 1. NASA/JPL/CALTECH

STELLAR ASTROPHYSICS

Spinning like a top

The giant eruptive variable star Eta Carinae is flanked by two mushroom-shape clouds, each bigger than the solar system and blown off by the star's wind of particles. Astronomers at the European Southern Observatory (ESO) have now zoomed in on the inner part of the stellar wind.

They found that Eta's stellar wind is highly elongated in the direction of the clouds. They also found that if this unstable star were spinning even 10 percent faster, it would break up. — ANDREW FAZEKAS

HIGH-SPEED WIND close to Eta Carinae shows that the star is very unstable. ESO

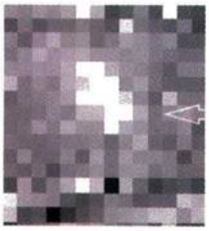
COMET MISSIONS

Stardust sees target

More than a month before its rendezvous with Comet Wild 2, NASA's Stardust probe, on a mission to collect the first-ever comet samples, took early photos of its quarry. The probe's navigation camera made the detection in November 2003 while still 15.5 million miles away.

Mission engineers will use the images to refine orbital data on the 3.3-mile-wide comet and narrow Stardust's trajectory. Project manager Tom Duxbury (JPL) adds that "by finding the comet as early and as far away as we did, the complexity of operations leading up to the encounter just dropped drastically."

Stardust will return its samples to Earth in January 2006. — **A. F.**



COMET WILD 2 was just a handful of pixels when Stardust imaged it last November. NASA

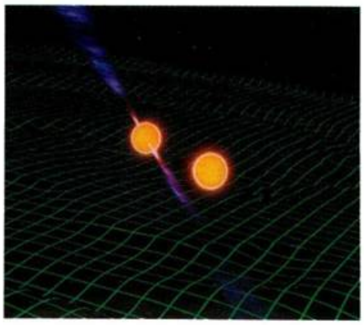
NEUTRON STARS

Pulsar makes waves; merger looms

Neutron stars — dense stellar remnants — collide and merge more often than astronomers thought, according to new results published in *Nature* (December 4, 2003). The findings come from a revised estimate (based on new observations) of how fast such systems decay and merge.

A team of astronomers led by Marta Burgay (University of Bologna) observed PSR J0737–3039, a double neutron-star system containing a pulsar.

The team found that this binary system is spiraling together more quickly than predicted. The team thinks the two stars are radiating gravitational waves, which would rob the system of orbital energy. The pair will merge about 85 million years from now. — **R. B.**



GRAVITATIONAL WAVES ripple the fabric of space-time as two neutron stars draw toward a merger. JOHN ROWE ANIMATION

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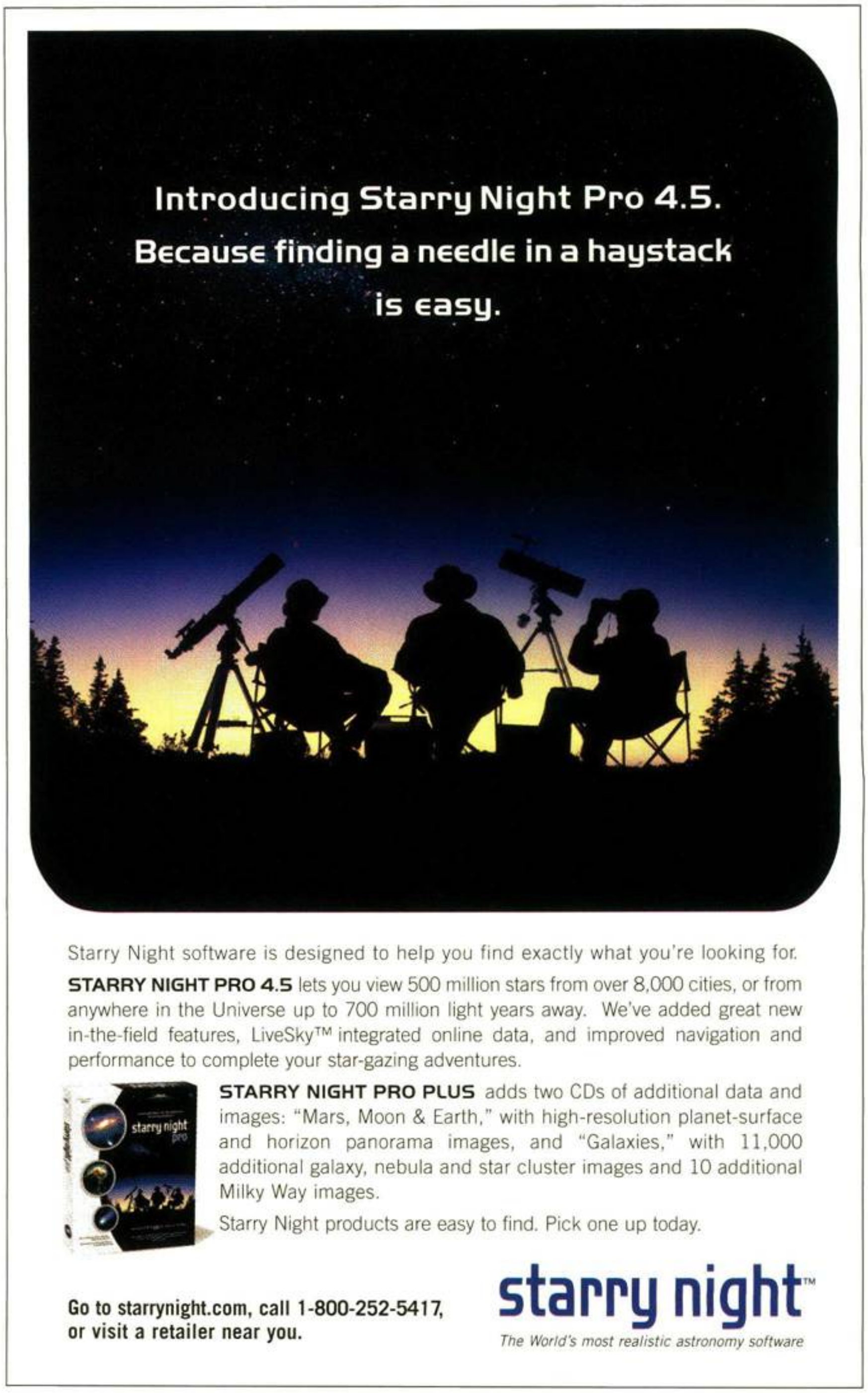
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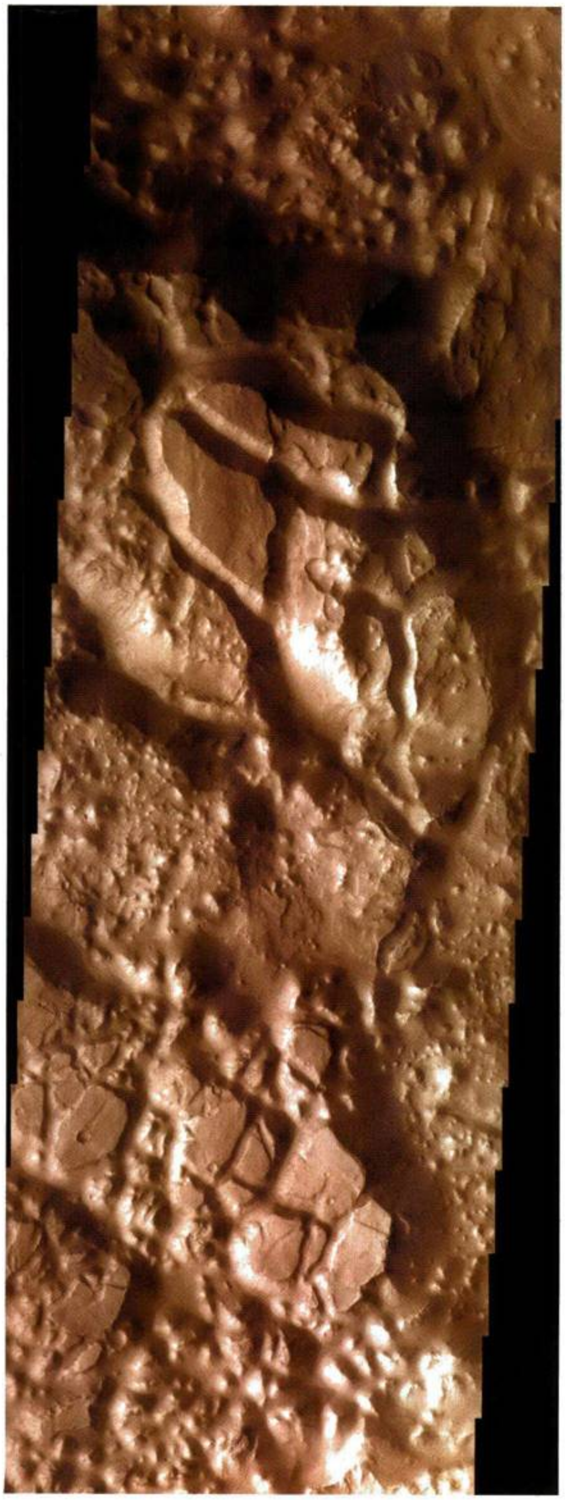
MARS'S CLIMATE MAY BE CHANGING, say scientists studying one martian year's data from the Mars Odyssey spacecraft. They found Mars has more water in low-latitude regions than it should have under current conditions.

Jumbled terrain



CHAOTIC COLLAPSE followed the melting of ground ice in sediments that filled Aureum Chaos. Huge floods resulted, leaving behind jumbled blocks and knobs of rock. NASA/JPL/ASU/IMAGE 20031111A

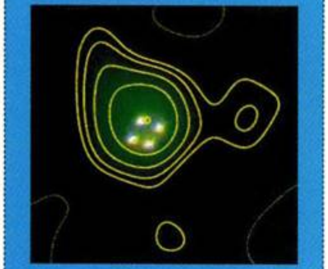
STAR FORMATION

Making stars quickly

Back when the universe was only 20 percent its current age, stars formed fast and furious, reports a team of astronomers using the Very Large Array radio telescope in New Mexico.

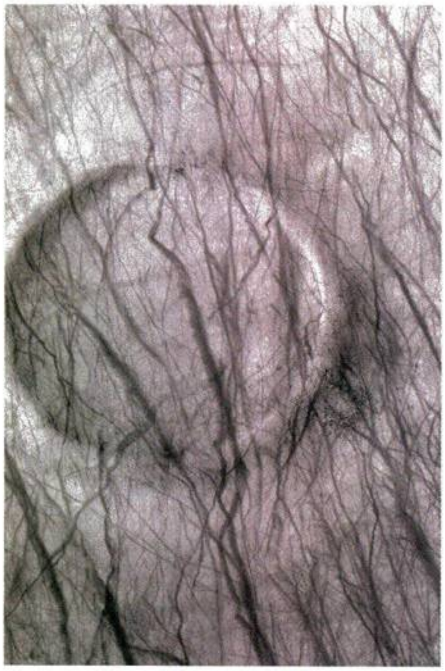
Studying a galaxy 11 billion light-years away, they discovered a huge quantity of dense interstellar gas. It is producing stars at a rate that would make a thousand Sun-like stars a year — a rate perhaps typical of the early universe.

"This rate is more than 300 times that of the Milky Way Galaxy now," says Philip Solomon (SUNY), one of the team. — R. B.



HYDROGEN CYANIDE emission shows where stars are forming quickly. NRAO/AUI/NSF/STScI

MARS PHOTOJOURNAL



DUST DEVIL TRACKS draw lines across an ancient crater by removing fine, bright dust and revealing darker bedrock. Newly deposited dust will erase these tracks by the time spring arrives at this location once again in 2005. Lit from the upper left, the image area is about 1.9 miles (3 kilometers) wide. NASA/JPL/MALIN SPACE SCIENCE SYSTEMS/IMAGE R09-01707

ASTEROIDS

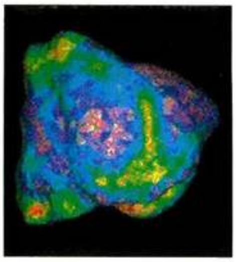
Moving worlds with sunlight

High-precision radar observations of asteroid 6489 Golevka show that its orbit has been altered by a very subtle thrust caused by solar heating. Called the Yarkovsky effect, the push had been seen on spacecraft, but this was the first time scientists have detected it on a natural body.

Steven Chesley (JPL) led the team that made the observations using radar from the Arecibo Observatory.

Yarkovsky thrust occurs when surfaces heated by sunlight radiate more strongly during the local afternoon than in the local morning. Depending on how a body's spin axis is oriented to its orbit, the thrust may increase the body's orbital velocity or reduce it. The effect works most strongly on smaller bodies.

Golevka, about a third of a mile across, passed close to Earth in May 2003. Earlier approaches in 1991, 1995, and 1999, also caught on radar, contributed to the discovery. — R. B.



ASTEROID GOLEVKA has had its orbit changed by roughly 9 miles, thanks to solar heating. NASA

Venus Transit Authority.

Total Venus Transit - June 8, 2004: $850

The last occurrence was in 1882, so this is truly a once-in-a-lifetime opportunity to witness the entire six hour transit. The Mediterranean is reknowned for clear skies, while our stunning new twins, *Olympia Explorer* and *Olympia Voyager,* are the world's fastest cruise ships–giving you mobility for the best viewing. You'll be joined by famed astrophotographers, George T. Keene and Richard Horwitz, who will bring the transit of Venus experience down to earth.

Total Solar Eclipse - March 29, 2006

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We've been helping people choose the right telescope since 1979. We have the experience to help you pick the scope that fits your needs (and your budget) from the hundreds of telescopes we stock. And, with our seven-figure inventory, we can usually ship you the right scope right away.

We started ***astronomics*** 25 years ago because we loved astronomy, not just as a business. Our sales may have grown over a thousand-fold since that first year, but we're still the same family-owned, family-run, full-line telescope dealer we were in 1979. And we still love astronomy.

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Fully automatic GPS (Global Positioning System) alignment takes the time and guesswork out of setting up your LX200 and aligning it on the heavens. You can start observing in mere minutes.

New and unique Smart Mount Technology can improve your scope's pointing accuracy as you observe. A supplied Lunar Planetary Imager will take color pictures for you.

The GPS Autostar computer hand control has a built-in database of over 145,000 stars and objects. It will find any of them for you *automatically*. You'll spend more of your time looking *at* heavenly bodies and less time looking *for* them.

Here are the LX200GPS scopes we ship from our stock:

7" Maksutov-Cassegrain	$2695⁰⁰
7" Maksutov-Cassegrain, w/UHTC	2845⁰⁰
8" Schmidt-Cassegrain	2195⁰⁰
8" Schmidt-Cassegrain, w/UHTC	2370⁰⁰
10" Schmidt-Cassegrain	2745⁰⁰
10" Schmidt-Cassegrain, w/UHTC	2980⁰⁰

Here are the LX200GPS scopes Meade ships from the factory due to their weight:

12" Schmidt-Cassegrain	3595⁰⁰
12" Schmidt-Cassegrain, w/UHTC	3890⁰⁰
14" Schmidt-Cassegrain	4695⁰⁰
14" Schmidt-Cassegrain, w/UHTC	5045⁰⁰
16" SCT, w/altazimuth pier and UHTC	15,645⁰⁰
16" SCT, w/equatorial pier and UHTC	15,845⁰⁰

Need a mount for your optics?
We have equatorial mounts from $349 to $84,150.

Losmandy
G-11

Granted, you usually won't find the $84,150 Takahashi computerized mount in stock, but we *do* keep a good inventory of those mounts priced under $10,000. Here's a *partial* list of the mounts we had in stock or readily available as this was written:

Celestron CG-5A, wood tripod, w/o drive	$349⁰⁰
ASCM, metal tripod, 2-axis go-to	699⁰⁰
CGE, metal tripod, 2-axis go-to	3000⁰⁰
Losmandy GM8, metal tripod, 2-axis drive	1449⁰⁰
GM8GT, metal tripod, Gemini go-to	2449⁰⁰
GM11, metal tripod, 2-axis drive	2079⁰⁰
GM11GT, metal tripod, Gemini go-to	3195⁰⁰
HGM Titan, metal tripod, 2-axis drive	5995⁰⁰
Meade Starfinder, w/pier, 1-axis drive	1995⁰⁰
LXD650, metal tripod, #1697 go-to	2595⁰⁰
LXD750, metal tripod, #1697 go-to	3595⁰⁰
Questar 7" Fork, no tripod, 1-axis drive	$6495⁰⁰
Software Bisque Paramount ME, no pier or tripod, 2-axis go-to drive	10,000⁰⁰
Takahashi P2Z, wood tripod, 1-axis drive	2219⁰⁰
EM-2S, wood tripod, 1-axis drive	2219⁰⁰
EM-10, wood tripod, 2-axis drive	2789⁰⁰
EM-10GT, wood tripod, Temma go-to	3589⁰⁰
EM-200, wood tripod, 2-axis drive	4449⁰⁰
EM-200GT, wood tripod, Temma go-to	5299⁰⁰
NJP/T, wood tripod, 2-axis drive	6049⁰⁰
NJP/TGT, wood tripod, Temma go-to	6949⁰⁰
NJP/P, pier, 2-axis drive	6049⁰⁰
NJP/PGT, pier, Temma go-to	6949⁰⁰
Vixen GP, metal tripod, no drive	800⁰⁰
GPW, wood tripod, no drive	980⁰⁰
GPDX, metal tripod, no drive	1220⁰⁰
GPDXW, wood tripod, no drive	1400⁰⁰
GPDXP, pier, no drive	1400⁰⁰
SPNX/T, metal tripod, Sphinx go-to	2165⁰⁰

Discovery Dobs are quality-made in the USA.

Why settle for an imported Dobsonian with only so-so mass-produced optics when premium made-in-the-USA quality costs no more? Discovery's optics are made to diffraction-limited standards by experienced optical craftsmen in California, one high quality mirror at a time. Discovery DHQ Dobsonians have a fast cool-down metal mirror cell, a thin vane diagonal spider, *two* 1.25" Plössl eyepieces, 2" metal rack and pinion focuser with 1.25" adapter, a built-in tube balancing system, tube carry handle, oversized bearings, 6 x 30mm finder, and a tube end dust cover.

Here are the prices for the fully-equipped Discovery DHQ Dobsonians. Freight from the factory in California is additional, as shown.

6" f/8 Discovery DHQ	**339⁰⁰** + $49 freight
8" f/6 or **f/7** Discovery DHQ	**449⁰⁰** + $49 freight
10" f/4.5 Discovery DHQ	**649⁰⁰** + $69 freight
10" f/5.6 Discovery DHQ	**649⁰⁰** + $69 freight
13.1" f/4.5 Discovery DHQ	**999⁰⁰** + $185 freight

> Thanks so much for the fast shipping! The product arrived on Thursday, in plenty of time for me to get it ready for my son's birthday. You guys are awesome!
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refractor
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Here is a listing of just a few of the premium TeleVue refractors that we keep in stock for immediate shipment.

Pronto, 2.7" f/6.8 semi-apo	**$1120⁰⁰**
TV-76, 3" f/6.3 apo	**1675⁰⁰**
TV-85, 3.35" f/7 apo	**2080⁰⁰**
TV-102, 4" f/8.6 apo	**2635⁰⁰**
Renaissance 102, 4" f/8.6 brass apo	**3175⁰⁰**
NP-101, 4" f/5.4 apo	**3595⁰⁰**

All of the above refractors come without a mount, but include an eyepiece (except the NP-101), an enhanced aluminum or 99% reflectivity Everbrite star diagonal, a carrying case, and a tube ring for mounting. Optical tubes only, without these accessories, are also available.

As for accessories, we have them all in stock. For example, here are a few of the newest eyepieces from TeleVue that we can ship today.

2-4mm 1.25" Nagler zoom	**$395⁰⁰**
2.5mm 1.25" Nagler Type 6	**280⁰⁰**
3.5mm 1.25" Nagler Type 6	**280⁰⁰**
11mm 1.25" Nagler Type 6	**280⁰⁰**
20mm 2" Nagler Type 5	**440⁰⁰**
41mm 2" Panoptic	**495⁰⁰**

Whether it's a Gibraltar, Panoramic, or Tele-Pod mount; a Sky Tour computer; a Nagler, Radian, Panoptic, or Plössl eyepiece; an Everbrite star diagonal; a Powermate or Barlow; a Nebustar light pollution filter, or a BinoVue – if it's from TeleVue, it's in stock.

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Meade 8" LX90

The **Meade LX90** lets you enjoy go-to astronomy for not a lot of money. The 8" LX90 with standard optical coatings is only $1695. UHTC (Ultra High Transmission Coatings) optics give you up to 20% brighter images for only $175 additional. The LX90 has a heavy-duty adjustable height tripod, 26mm Super Plössl eyepiece, Autostar computer with 30,223 star and object memory, 8 x 50mm finder.

We usually have the LX90 in stock at all times (both standard and UHTC versions), so you can probably get *your* LX90 with little or no delay. If Meade is shipping the LX90 *(or any Meade telescope)* for a dealer to keep in stock, the chances are very good we *have* it in stock.

Vixen scopes and mounts are in stock.

Vixen

Not only telescopes and mounts, but the complete range of Vixen accessories as well – Lanthanum long eye relief and wide angle long eye relief eyepieces, camera adapters, filters, focal reducers, Barlows, and more. Whether it's a telescope, mount, or accessory, if it's from Vixen, chances are good we have it in stock.

Here's a *partial* list of the complete Vixen scopes we had in stock as this was written:

V102MG, 4" achromat, GP mount	**$1350⁰⁰**
VE80SG, 3.1" ED apo, GP mount	**1655⁰⁰**
VE102SG, 4" ED apo, GP mount	**2200⁰⁰**
VF80SG, 3.1" fluorite apo, GP mount	**2280⁰⁰**
VF102SG, 4" fluorite apo, GP mount	**2900⁰⁰**
VR200G, 8" f/4 reflector, GP mount	**1700⁰⁰**

If you want a Vixen optical tube only, we stock their achromats, fluorite apos, ED apos, and dual ED apo refractors. We also stock Vixen's reflector and catadioptric optical tubes, and the well-known and highly-rated Vixen Great Polaris and Great Polaris DX German equatorial mounts to use with your own optics.

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Vixen VE102SG
4" f/9 ED apo refractor
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If city lights wash out your view of the skies, get rid of the pollution with one of the 38 different light pollution reduction filters we stock.

We have two **Celestron** broadband filters. One is designed for 1.25" eyepieces; one for Schmidt-Cassegrain (SCT) rear cells.

We have 13 **Lumicon** Deep Sky broadband, UHC narrowband, and H-Beta and Oxygen III line band filters for use in 1.25" and 2" eyepieces, as well as on SCT rear cells.

We have six **Meade** broadband, narrowband, and Oxygen III filters in 1.25" eyepiece and SCT rear cell versions.

We have four **Sirius** contrast enhancement and nebula filters for 1.25" and 2" eyepieces, plus a unique 1.25" *variable* nebula filter.

We have four **TeleVue** Bandmate NebuStar UHC-type narrowband and Oxygen III filters in both 1.25" and 2" eyepiece versions.

We have eight **Thousand Oaks** broadband, narrowband, Oxygen III, and H-Beta filters in both 1.25" and 2" eyepiece versions.

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The **Vixen Sphinx** telescopes and mounts take the mystery out of go-to astronomy. You don't have to know Messier, NGC, or IC numbers to have your scope find deep sky objects.

Simply move the crosshair cursor over the object displayed on the Star Book hand control's 4096-color LCD star chart screen. Push a button and the Sphinx mount moves to that object. Zoom-In/Out buttons for the star chart display also control the motor speed. As you zoom in on an object displayed on the screen, the motor speed automatically slows for more accurate control. Zoom out and the motor speed increases to cover large distances quickly.

Vixen Star Book hand control showing star chart display

The Star Book control's 4MB flash ROM memory can be updated from the Internet to keep you current with the heavens. And the easy-to-use Star Book controller can be used as a stand-alone star atlas to learn the skies anywhere, anytime.

The Sphinx go-to mount with Star Book controller is available separately for use with your own optics. It is also available in ultra-premium Vixen telescope packages that range from an 3.1" f/5 refractor on a supremely portable tabletop go-to mount to big 8" reflectors and catadioptrics on full length field tripods.

FL80SWT-SXW 3.1" f/8 fluorite apo Vixen refractor on Sphinx go-to mount

$3910

You'll find full Vixen Sphinx details and prices on our **www.astronomics.com** website.

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Right angle finders available from stock from $89.

We stock **Antares** 8 x 50mm and 11 x 80mm right angle finders from $89 to $217.50. Choose from gloss white, Celestron black, or Meade blue in your choice of a mirror-image or erect right-reading version that shows you the sky the way it appears on star charts. Optional mounting rings are also available.

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Black holes i

Astronomers know about small black holes — and about the supermassive ones in the cores of galaxies. But how does nature make the big guys out of the little ones?

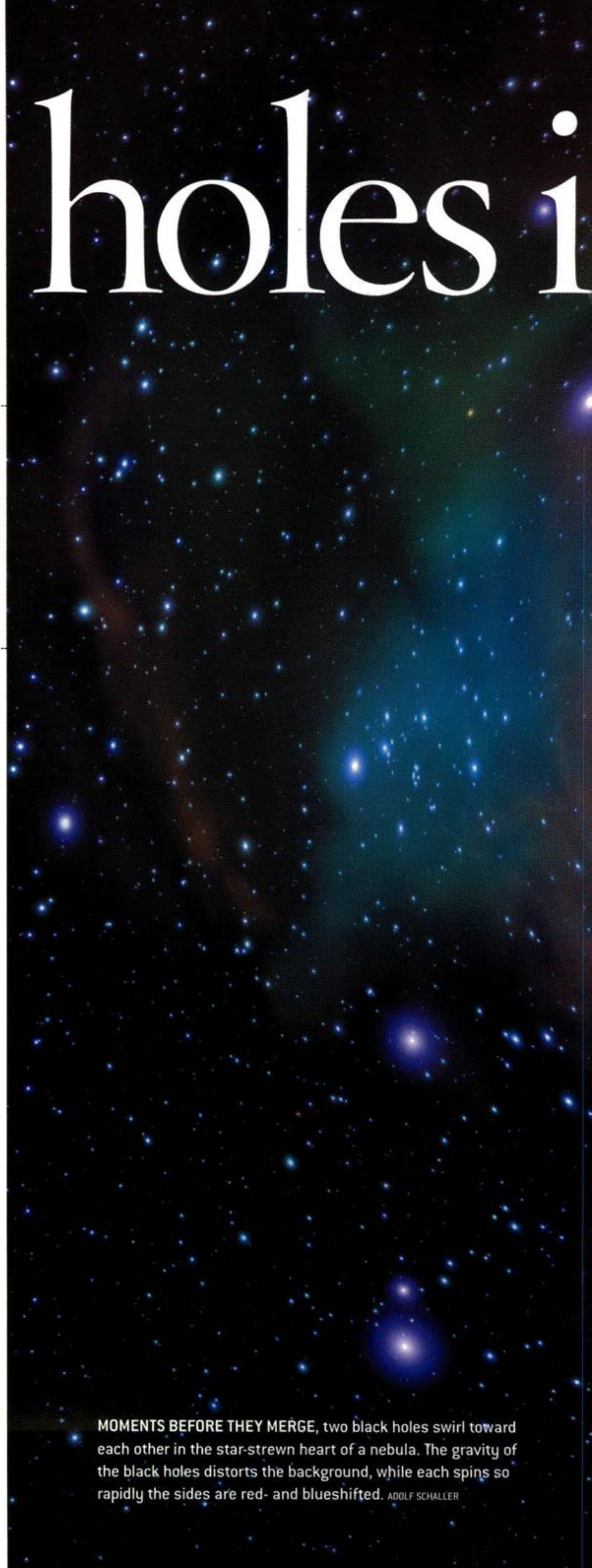
/// BY STEVE NADIS

Few mysteries in astronomy have the allure of supermassive black holes and their murky origins. For astronomers, the question comes down to: How can an object as massive as a million to a billion suns form in the middle of a galaxy? A possible answer can be found in William Shakespeare's *Twelfth Night*: "Some are born great, some achieve greatness, and some have greatness thrown upon them."

Astronomers know that supermassive black holes don't start with a billion solar masses, but instead grow in step with their host galaxies. While that eliminates the born-great option, it still leaves the question of how modest black holes might achieve greatness.

Both theorists and observers feel confident about the existence of stellar-size black holes. These form when a star of roughly 10 solar masses collapses after a supernova explosion. (Ten such objects have been positively identified in the Milky Way out of an estimated 100 million stars.) Yet virtually no astronomer thinks these diminutive black holes could be the building blocks for beasts of the supermassive variety. Why? Because it would take too long to assemble a giant black hole one small brick at a time.

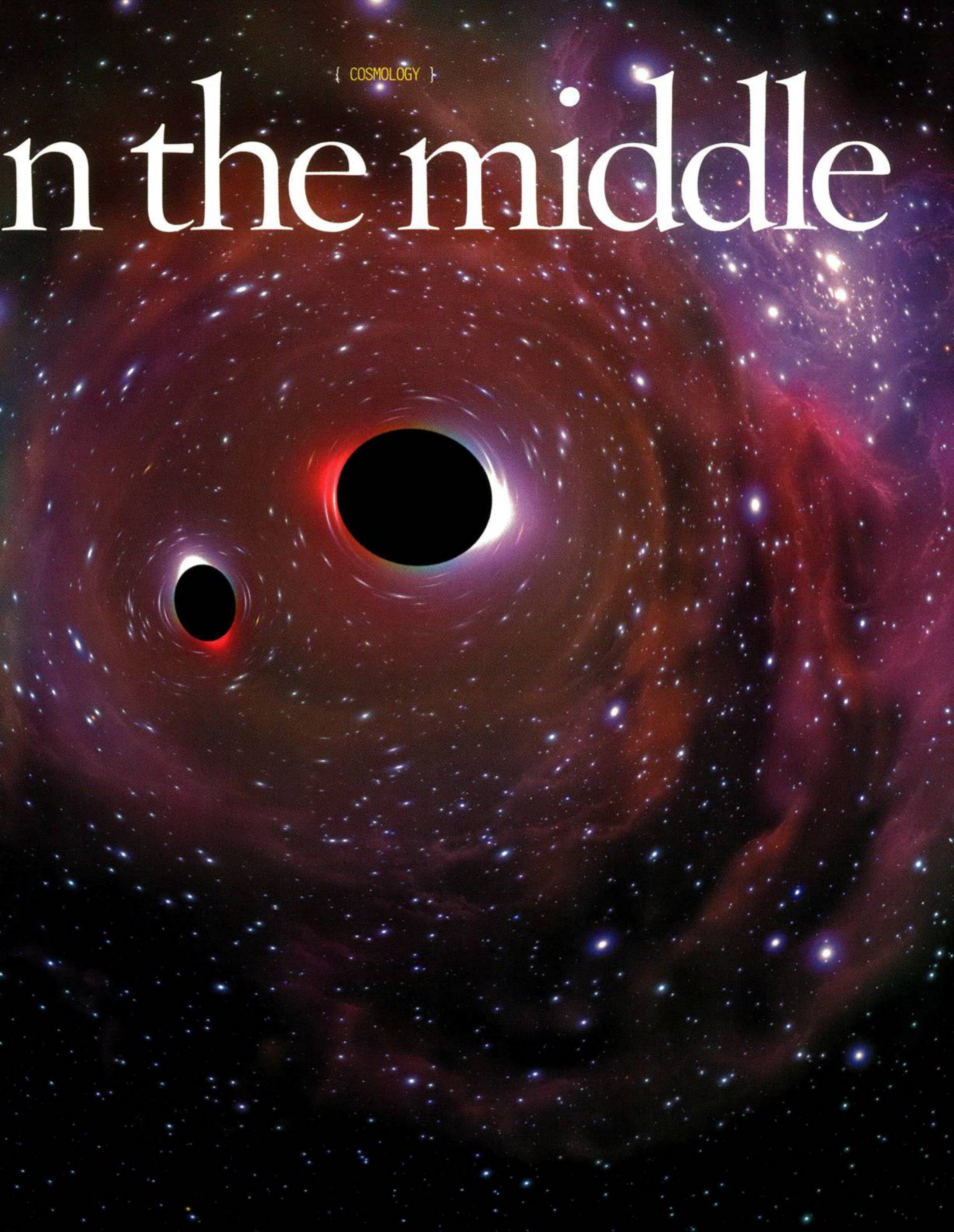
Over the last few years, optical and X-ray observations have hinted at the existence of a black hole middle ground — a class of black holes with masses of perhaps 100 to 10,000 suns. This places them somewhere between stellar-size objects and the behemoths of galactic cores. These mid-size, or intermediate-mass black holes (IMBHs), may be the missing link that provides the seeds for the gigantic ones. The pursuit of these objects, not surprisingly, has become a very hot field among black-hole hunters.

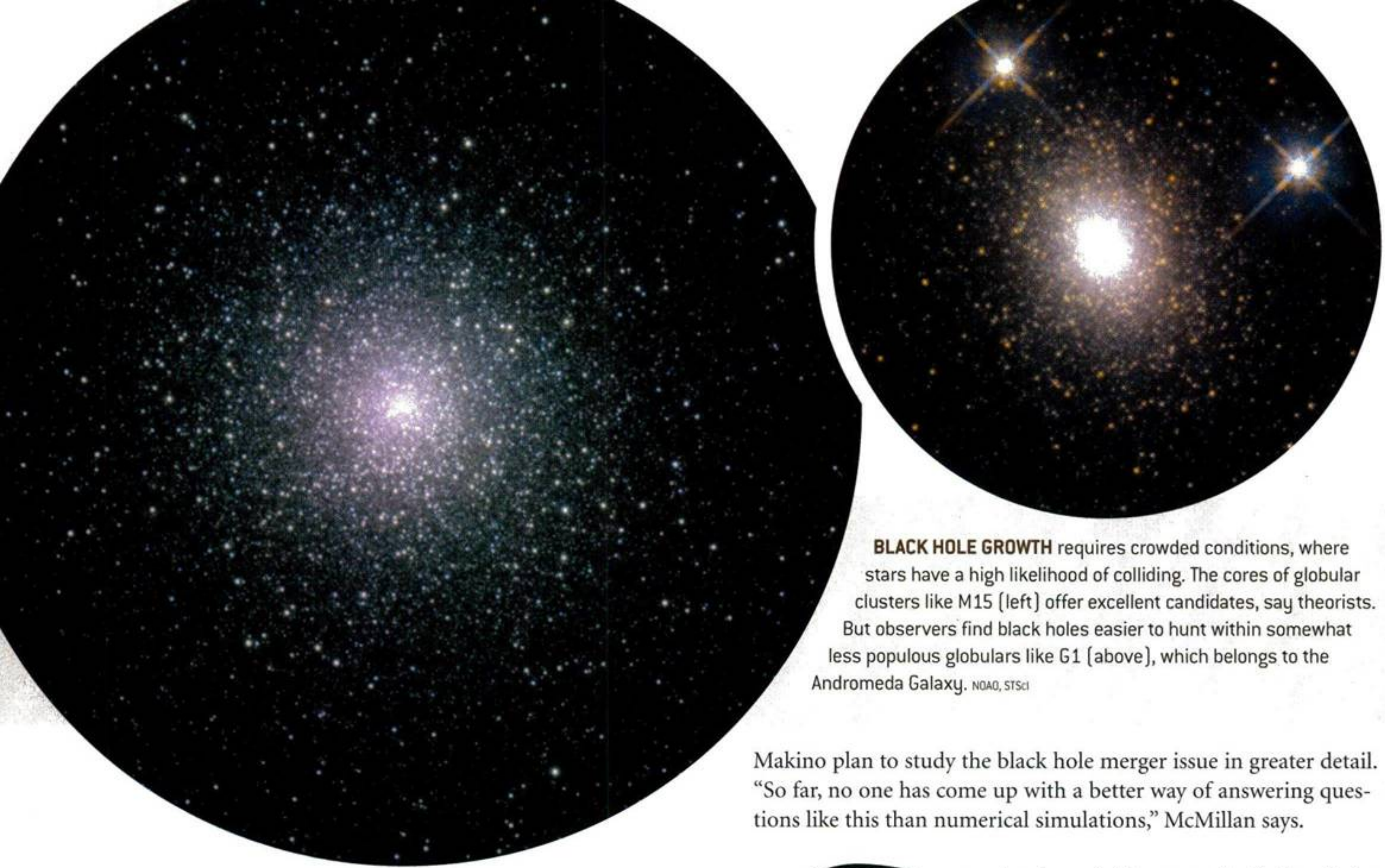


MOMENTS BEFORE THEY MERGE, two black holes swirl toward each other in the star-strewn heart of a nebula. The gravity of the black holes distorts the background, while each spins so rapidly the sides are red- and blueshifted. ADOLF SCHALLER

{ COSMOLOGY }

n the middle





BLACK HOLE GROWTH requires crowded conditions, where stars have a high likelihood of colliding. The cores of globular clusters like M15 (left) offer excellent candidates, say theorists. But observers find black holes easier to hunt within somewhat less populous globulars like G1 (above), which belongs to the Andromeda Galaxy. NOAO, STScI

The theoretical groundwork for this effort has been laid by a group of investigators — including Piet Hut of the Institute for Advanced Study in Princeton, New Jersey, and Junichiro Makino of the University of Tokyo — that uses N-body computer simulations (with up to 300,000 stellar objects) to show how IMBHs could form in young clusters populated by large stars. In their "runaway merger" scenario, a given cluster is dense enough that stars collide often. After its stars lose kinetic energy in these exchanges, the most massive ones sink to the center. As the central density increases, collisions become more frequent. Stars stick together during crashes and one star, through chance, grows bigger than the others. Within five million years or so, all the other stars in the system will merge with the dominant star, which eventually collapses to form an intermediate-mass black hole.

> M15 is the worst possible place to look for a black hole.

As many star clusters sink to the center of the galaxy, they bring intermediate-mass black holes to the core, where they merge with a central black hole. The latest simulations suggest this may be the fastest way to build supermassive black holes, claims Drexel University's Steve McMillan. In addition, these simulations show that a competing scenario — in which two galaxies merge, each with its own supermassive black hole — stalls when the two supermassive black holes kick nearby stars out of their vicinity, choking off growth. Later this year, McMillan and Makino plan to study the black hole merger issue in greater detail. "So far, no one has come up with a better way of answering questions like this than numerical simulations," McMillan says.

Computers haven't taken over the field entirely, however. Activity among X-ray, optical, and radio astronomers is quite intense. "When you're in the middle of a very hot field, you can be sure everyone is trying everything," notes John Kormendy of the University of Texas. Findings tend to be controversial because the objects under study lie close to current detection limits. There are two main ways to spot an intermediate-mass black hole, both indirect. When a black hole feeds on gas or a nearby star, matter forms an accretion disk that swirls around the black hole. The material heats up and emits X rays before spiraling into the black hole. Astronomers can gauge the black hole's mass by the amount of X-ray emission. The second approach examines how the black hole's gravity affects its surroundings. Stars orbiting a black hole speed up in ways that depend on the black hole's mass as they draw near the event horizon.

Because intermediate-mass black holes are small compared to their galactic counterparts, their traces are subtle and easy to overlook. And where measurements are extremely difficult, mistakes occur. In September 2000, for example, a team led by Philip Kaaret at the Harvard-Smithsonian Center for Astrophysics (CfA) announced it had detected an oscillation in the luminosity of an X-ray source in the starburst galaxy M82. Kaaret and his colleagues viewed this as evidence for a black hole with a mass of 500 or more suns. A few weeks later, they realized the oscillation

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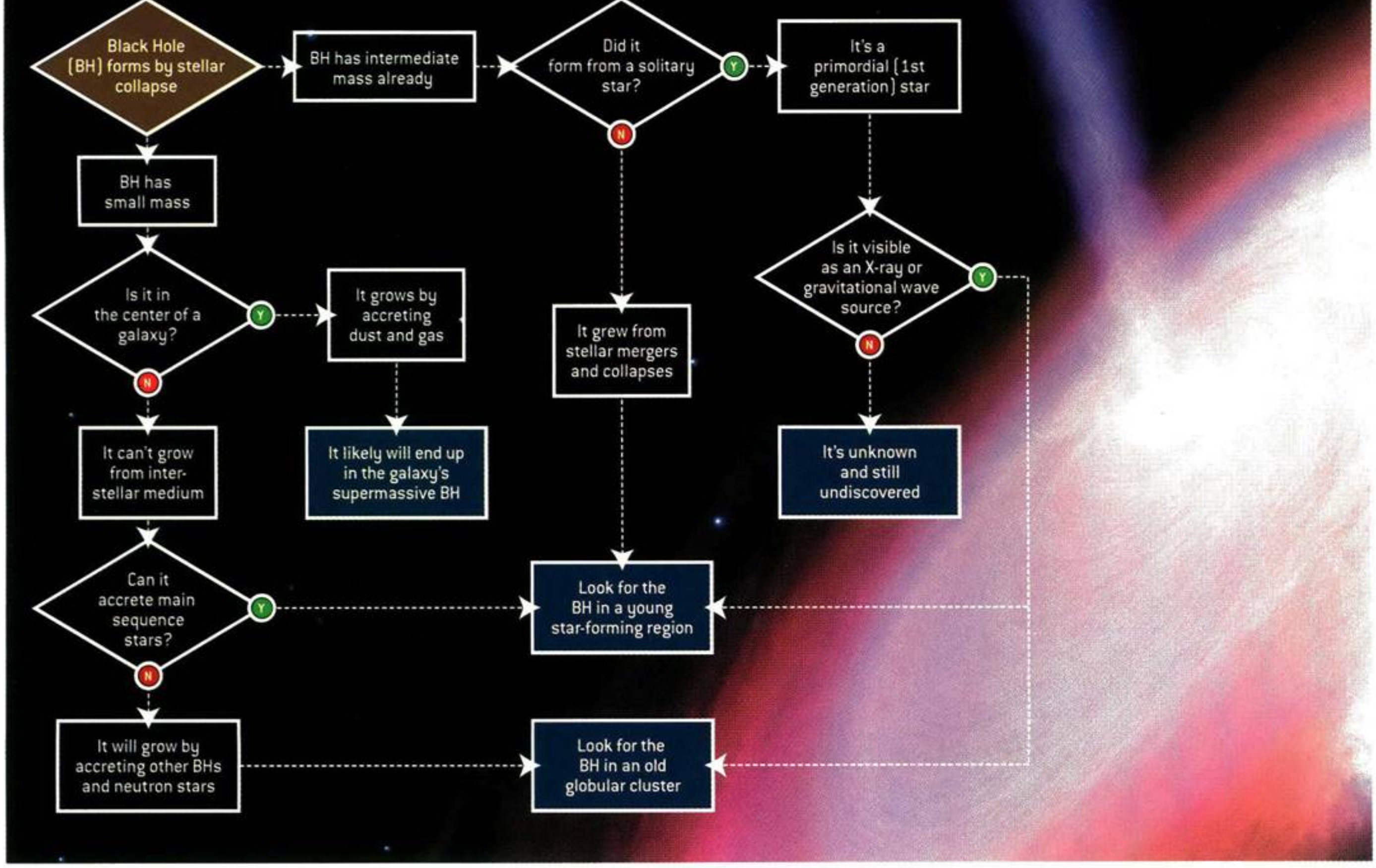
Steve Nadis *is a science writer who lives in Cambridge, Massachusetts.*

/// HOW TO DISCOVER AN INTERMEDIATE-MASS BLACK HOLE

PATHS TO BLACK HOLE GREATNESS can take many turns. But they all lead astronomers to look for mid-size black holes in two likely places: old, dense clusters [such as globulars] and young, dense clusters [massive star-forming regions]. BACKGROUND IMAGE: ADOLF SCHALLER


Black Hole [BH] forms by stellar collapse
BH has intermediate mass already
Did it form from a solitary star?
Y
It's a primordial [1st generation] star
N
BH has small mass
Is it visible as an X-ray or gravitational wave source?
Y
N
Is it in the center of a galaxy?
Y
It grows by accreting dust and gas
It grew from stellar mergers and collapses
N
It can't grow from interstellar medium
It likely will end up in the galaxy's supermassive BH
It's unknown and still undiscovered
Can it accrete main sequence stars?
Y
Look for the BH in a young star-forming region
N
It will grow by accreting other BHs and neutron stars
Look for the BH in an old globular cluster

was caused by instrumental error — an aberrant camera on the Chandra X-ray Observatory.

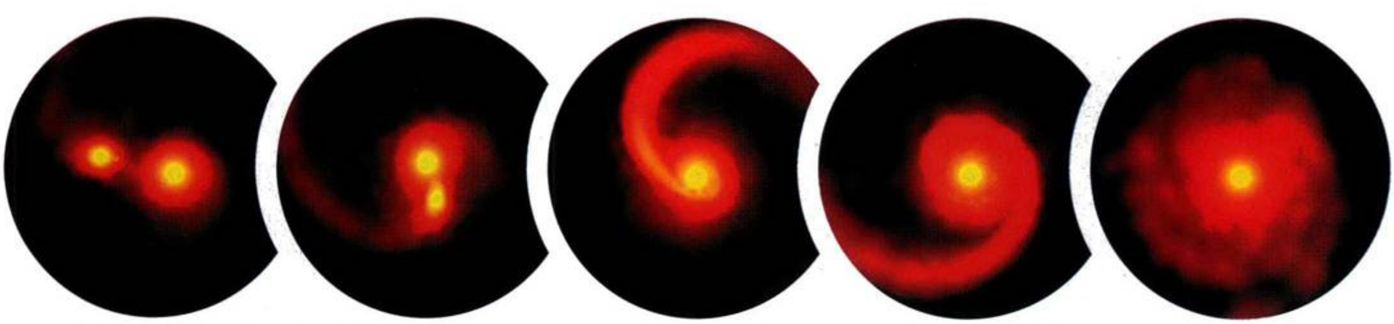
Similarly, in September 2002, a team led by Roeland van der Marel of the Space Telescope Science Institute announced they'd found signs of a 4,000-solar-mass black hole in M15 (a globular cluster in the Milky Way) using the Hubble Space Telescope (HST). Within weeks of their press release, however, the team learned they'd based part of their analysis on a flawed journal article. When they revised their calculations, the presence of the intermediate-mass black hole became "much more ambiguous," according to van der Marel.

"This subject is a trap for the unwary," notes University of Michigan astrophysicist Douglas Richstone. Despite the missteps, the sources in M82 and M15 are still considered viable mid-range black hole candidates. In fact, some experts like University of Maryland astrophysicist Cole Miller believe the M82 source is the best candidate yet identified.

The object in M82 is the brightest ultra-luminous X-ray source (ULX) known. Researchers use the brightness of a ULX to estimate the mass of its black hole — the brighter the ULX, the more mass it has. In this case, Kaaret and his colleagues concluded that the object contains a mass of at least 500 suns — well above the stellar black hole range — to generate enough gravity to overcome the force of outgoing radiation and draw in sufficient matter to sustain the high X-ray emission. A 10-solar-mass black hole could not be this bright because it would exceed the Eddington limit. This is the point where the outward radiative force exceeds the inward tug of gravity and accretion shuts down.

There is, however, a possible loophole — a way to account for ULXs like M82's without invoking objects as massive as intermediate-mass black holes. If radiation from the black hole is expelled in a narrow jet rather than sprayed uniformly in all directions, a much smaller (stellar-size) and less energetic black hole could explain the X-ray luminosity. To investigate this possibility, Kaaret will make simultaneous observations of M82 in X rays with Chandra and in radio waves with the Very Large Array four times over the course of 2004. "If the emissions are really coming from a jet, the X-ray and radio data should vary together," he explains. "Then we'll know for sure it's beamed."

Astronomers have cataloged more than 100 ULXs to date. "Most are probably 10-solar-mass black holes, but a few may turn out to be IMBHs," says CfA astronomer Jon Miller. In the spring of 2003, Miller and other collaborators identified two ULXs, X-1 and X-2, in spiral galaxy NGC 1313 that may be black holes of 100 to 500 solar masses. Miller was drawn to these sources by their luminosity and the relative coolness of their accretion disks, as determined by spectral analysis. Counterintuitively, a cool disk indicates a black hole larger than a stellar-size one because the event horizon is larger and there's more surface area over which to radiate energy — hence the lower temperature.



CIRCLING THE DRAIN, an 18 solar-mass star is absorbed into a 58 solar-mass star following their grazing collision. The crowded conditions in globular clusters and in dense regions of new star formation make such collisions relatively frequent. JAMES LOMBARDI, VASSAR COLLEGE/STEVE McMILLAN, DREXEL UNIVERSITY

Beaming is always an issue in such cases. "If we were looking down the barrel of a jet, you'd expect to see bright radio emissions as well as X rays," Miller contends. "So far, no one has seen that in X-1, despite extensive radio observations." However, he notes, radio astronomers have not explored the X-2 region as thoroughly. "NGC 1313 is a rather large galaxy, and coverage varies from section to section."

If radiation is beamed through wide cones rather than pointed jets, that might be evident in the shape of the nebulae — the gas and dust clouds — surrounding the X-ray sources. But optical observations by Manfred Pakull and Laurent Mirioni, both of Strasbourg Observatory, show the nebulae around X-1 and X-2 are fairly symmetric, lacking the elongated lobes expected if X rays were being beamed.

Pakull also discovered a nebula enveloping a ULX called X-9 in the galaxy Holmberg II. After intercepting the X rays, the nebula ionizes and sends out unbeamed optical radiation. "The optical emission tells us the total energy, and the emission we see is consistent with the source not being beamed," Cole Miller explains.

But even if the beaming argument is overcome in these examples, the IMBH candidates may still be only stellar-size black holes, argues University of Colorado astrophysicist Mitchell Begelman. He proposes that radiation leaks out the sides of an accretion disk without blowing away incoming gas. "The radiation doesn't shoot out like a jet," he says. "The accretion disk is porous like Swiss cheese and the radiation comes out through the holes." If his view is confirmed, mass estimates for putative mid-range black holes might be downsized to the stellar range.

> The accretion disk is porous like Swiss cheese, and the radiation comes out through the holes.

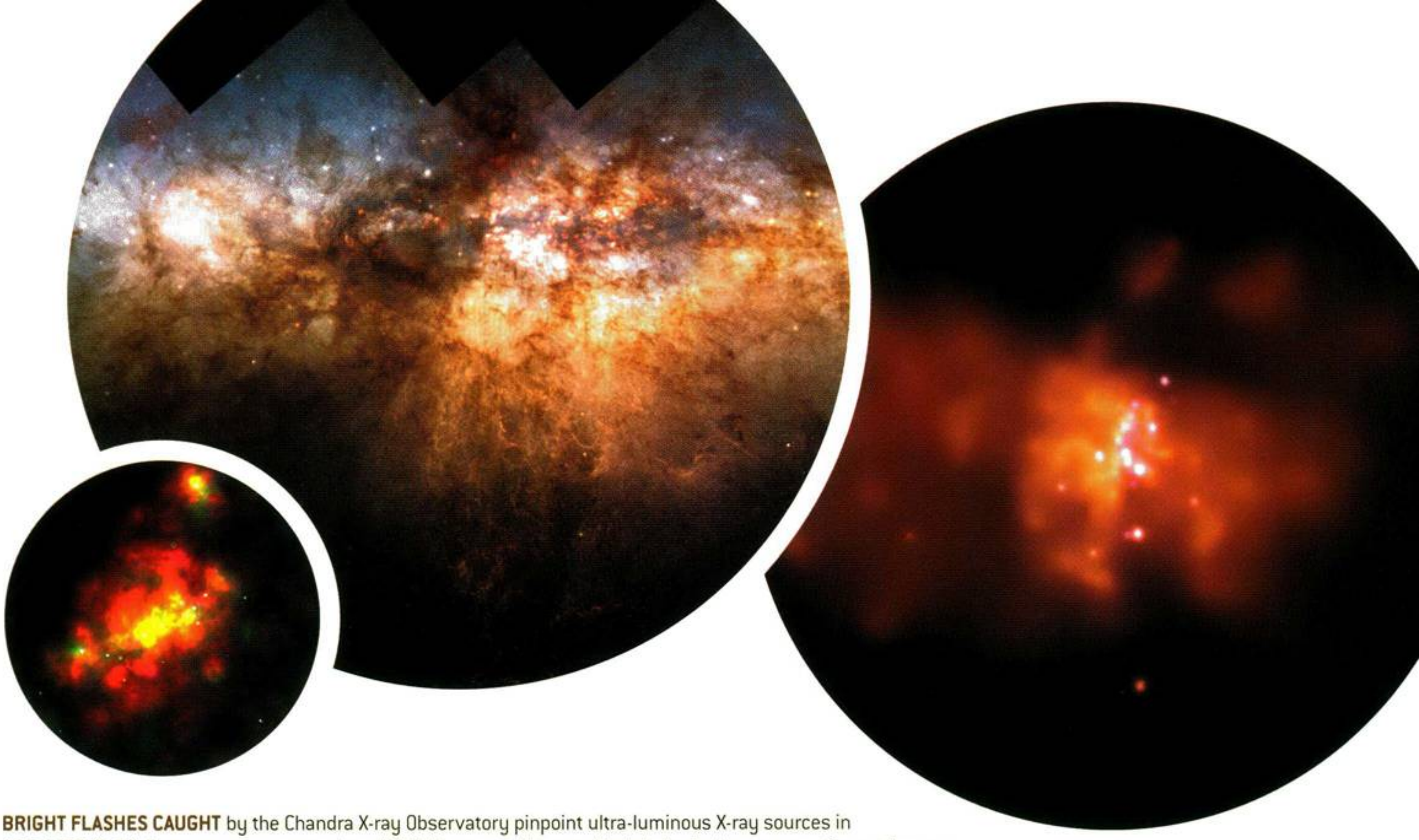
In the midst of imperfect data and malleable theories, it's not surprising that interpretations are varied and opinions divided. A similar controversy prevails on the optical front. The alleged medium-size black hole in M15 serves as an example. "Everyone agrees there's a dark mass in the cen*ter of the cluster* causing stars to speed up," van der Marel says. "But what *is* that dark mass?" Is it a large black hole, as originally claimed, or could it be white dwarfs and neutron stars — the normal "dark remnants" that would be expected to collect there anyway? Simulations by the N-body team, this time headed by University of Tokyo's Holger Baumgardt, indicate that "no central massive object is required to explain the observational data, although we cannot conclusively exclude such an object."

"In the end, I agree with them," says van der Marel. His collaborator, University of Texas astronomer Karl Gebhardt, still leans toward the intermediate-mass black hole interpretation but thinks the evidence is even stronger with globular cluster G1. The case for G1 is more compelling, Gebhardt maintains, because the cluster is much less dense than M15. Consequently, fewer white dwarfs and neutron stars would pile up in the center. For this reason, the uncertainties about the inferred black hole in G1 are much smaller than in M15. "M15 is the worst possible place to look for a black hole," he says. "It's where you'd expect to find one, but observationally, the task is very difficult." Perhaps not surprisingly, however, the Baumgardt group is not persuaded by the G1 example either. They claim their dynamical model fits the observational data without invoking the presence of an IMBH.

Undeterred, Gebhardt arranged to point HST at two other clusters in the Andromeda Galaxy. "Their central density is even lower than G1's, which greatly reduces the dark remnant problem," he says. "If we see increased velocity toward the center of these clusters, it's almost bombproof." He's also monitoring fifteen clusters with ground-based optical telescopes. "You can do better with a bigger telescope on the ground like Gemini than you can with Hubble, provided you choose the right cluster."

Meanwhile, astronomers are exploiting another technique for obtaining stellar velocities. Instead of determining velocity from the redshift and blueshift of a star's absorption spectra, stellar movements can be charted directly through their actual changes in position. The Hubble Space Telescope has been in orbit since 1990; by examining high-resolution images of a star taken five or so years apart, astronomers can see exactly how far it has moved. A Yale University team headed by Gordon Drukier is pioneering this technique, which has long-term potential for clarifying the dynamics of globular clusters.

But what if intermediate-mass black holes aren't feeding on nearby gas or stars and therefore reveal no obvious signs of their



BRIGHT FLASHES CAUGHT by the Chandra X-ray Observatory pinpoint ultra-luminous X-ray sources in NGC 4485 (left). Astronomers suspect these "ULXs" betray mid-range black holes in the process of accreting gas and stars. Supermassive black holes dwell in the cores of most, if not all, large galaxies such as M82 (center; seen by HST). Chandra's X-ray eye spotted bright sources near the galaxy's center (right). They are good candidates for intermediate-size black holes still absorbing material and growing. CXC, CXC, STScI

existence? In that case, the only known strategy that might work is to look for a "microlensing event" — a brightening of a star's light caused by an unseen mass between the source and an observer. VISTA, an infrared telescope now being built in Chile by a United Kingdom consortium, is probably the best instrument for a microlensing survey, says Notre Dame astronomer David Bennett, although he admits the facility hasn't selected an official project list. "Since we don't have a good handle on the abundance of IMBHs, I can't guarantee we'd detect these objects with such a survey."

At the moment, both the reality of mid-size black holes and their prevalence remain open questions to all but the most enthusiastic advocates. The state of the art is about where the supermassive black hole field was in the mid-1980s, says Kormendy. "The first believable [supermassive black hole] detection was published in 1988, and things have gotten better since then. Now it's hard to find skeptics."

IMBH skeptics, however, are easy to find, although a broad consensus feels the subject warrants further study. Much of the interest stems from the premise that a modest black hole — no more than 10,000 solar masses, according to Gebhardt — is all it takes to seed a supermassive one. But do black holes come in such mid-level sizes, or is there a cutoff at, say, one million solar masses, below which these objects don't form?

Kormendy, for one, has doubts about the current mid-range black hole data, although he desperately wants to believe: "I hope the proponents are right, but you can't let wishful thinking take you ahead of the facts." While mid-size black holes would be convenient from a theoretical standpoint, he adds, we would not be at a total loss without them. "There's a lot of physics regarding galaxy formation we don't yet understand, which raises possibilities," he says.

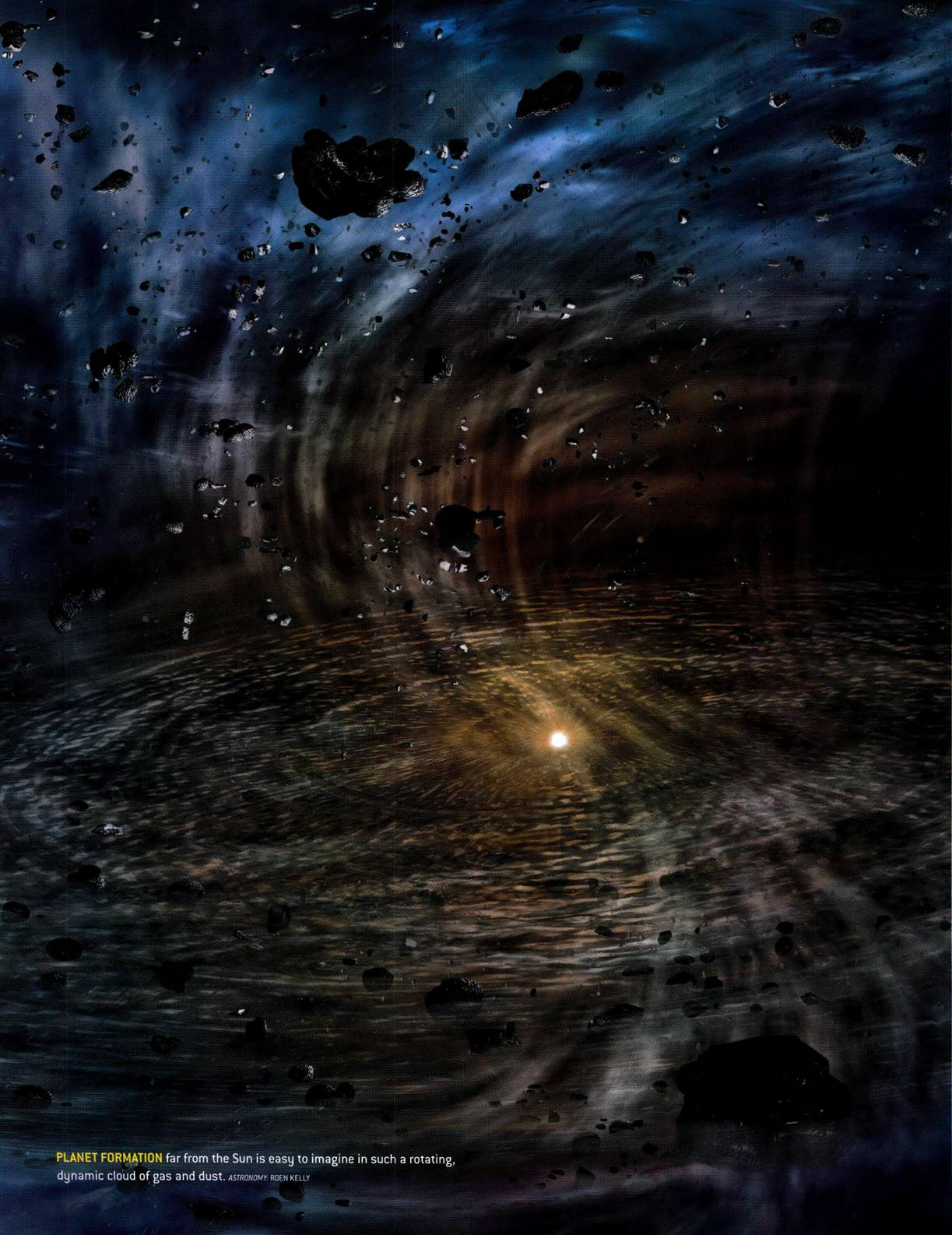
Richstone, for instance, can imagine creation stories for supermassive black holes that don't involve IMBHs, globular clusters, or ULXs. The entire process, he says, can occur in galaxy centers following the collapse of giant gas clouds.

After many years of groping in the dark, says van der Marel, "observational techniques are just reaching the point where we can get some answers. We should know within twenty years whether or not IMBHs exist."

Gebhardt is more optimistic, thanks to the emergence of integral field units (IFUs) — a new technology being installed on leading telescopes like Gemini, Keck, and the VLT. In the past, astronomers had to look at tiny pieces of the sky to obtain spectral measurements of individual stars. The new technology, however, can take the spectra of all the bright stars in a field. "It's the ideal instrument for globular clusters, which are in turn the best candidates for IMBH breeding grounds," says Gebhardt. "This instrument is not just more efficient but flat-out better." Within a few years, he predicts, we'll know whether intermediate-mass black holes are there and, if so, their abundance.

If he's right, we'll soon have a clearer picture of how black holes "achieve greatness," to snatch a phrase from Shakespeare once again. Isaac Newton claimed he was able to see farther by standing on the shoulders of giants. In the case of supermassive black holes, greatness may emerge from the ranks of the mediocre — middling objects that, through a combination of luck and hunger, grow without bounds, ultimately becoming among the universe's most powerful engines.

To see computer-animated simulations of mid-size black holes in formation, visit www.astronomy.com/toc



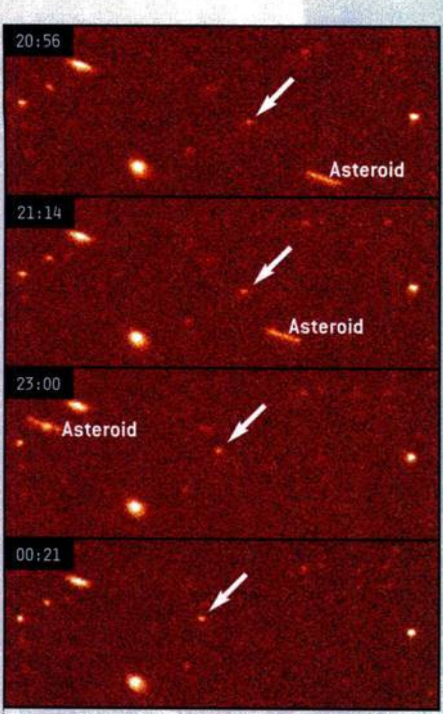
PLANET FORMATION far from the Sun is easy to imagine in such a rotating, dynamic cloud of gas and dust. *ASTRONOMY:* ROEN KELLY

Cosmic snowstorm

Far from their central star, planets in the outer reaches of the solar system may form the same way snowflakes do on Earth. /// BY SCOTT KENYON

Wilson Bentley looked expectantly at the storm clouds moving up behind the tall pines toward the southwest. He adjusted his mittens and inhaled the frigid Vermont air. Soon, the snowfall began. The self-taught farmer caught a few snowflakes on his one-foot-square blackboard. Hurrying indoors, Bentley transferred each flake to a glass slide under a microscope. He held his breath, focused his camera, and waited for the exposure. Ten seconds. Twenty. As he took the world's first photographs of snowflakes, he wondered how temperature affected the snowflakes' shapes. His records showed that warmer storms produced delicate filigree designs. The coldest storms, on the other hand, gave rise to snowflakes shaped like needles and columns.

That was the 1880s. Today, snowflakes are grown in laboratories. In frigid conditions outdoors, water vapor condenses directly onto a grain of dust and forms an ice crystal, which grows as more vapor condenses. Once the snowflake is heavy enough, it falls to Earth. Its shape depends on temperature and humidity — simple crystals



THE FIRST KUIPER BELT OBJECT was discovered by astronomers David Jewitt and Jane Luu using the University of Hawaii's 2.2-meter telescope on Mauna Kea. Discovered in the summer of 1992, the object was dubbed 1992 QB, and appears to have a diameter of about 120 miles. DAVID JEWITT AND JANE LUU

QUAOAR is the ungainly name given to the largest KBO detected since the discovery of Pluto's moon Charon in 1978. Spotted in 2002, Quaoar (pronounced kwa'-wahr) is about half Pluto's diameter and lies about a billion miles beyond that planet's orbit. This illustration shows what Quaoar might look like up close; the KBO is too far away for telescopes to resolve its surface. ILLUSTRATION BY NASA AND G. BACON

grow in dry conditions and become more complex as humidity rises.

Four and a half billion years before Bentley's snowflake pictures, similar icy grains began to fall in the outer reaches of the solar system. At a certain temperature and pressure, methane and water condensed onto small carbon or silicate grains. The icy grains developed complex shapes, perhaps chains or needles. Like snowflakes falling to Earth, the grains collected at the outskirts of the dusty disk surrounding the newborn Sun. There, they collided and stuck together to form larger objects that eventually became planets. The result — Pluto, its moon Charon, and a vast assemblage of icy bodies outside Neptune's orbit — is called the Kuiper Belt. How these icy grains formed, fell, collided, and grew is mostly unknown, but my colleague Ben Bromley, an astrophysicist at the University of Utah, and I have created computer models in an attempt to solve this mystery.

Planets from snowflakes

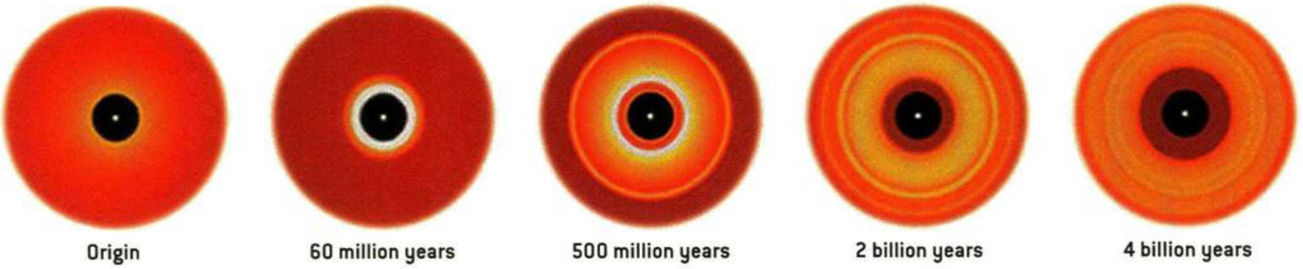
Most theories of planet formation begin with a solar nebula, a disk of gas and dust orbiting a newborn star. In addition to the Sun, every object in our solar system — be it asteroid, comet, or planet — formed from the solar nebula. Two theories — coagulation and dynamical instability — try to explain the incredible variety of objects we see. In the century-old coagulation theory, large planets form by collisions and mergers of smaller objects embedded in the solar nebula, like a snowball that grows as it rolls down a snowy slope. According to the more recent dynamical instability theory, part of the nebula collapses spontaneously into a planet. This scenario is more like an avalanche than a growing snowball.

Testing the hypothesis is difficult. Because we cannot travel back in time, we do not know how our solar system's planets formed.

The coagulation model, which Ben and I favor, is familiar in everyday life. Dust bunnies under your bed grow through the gradual accumulation of bits of paper, dust, and hair around your home. In much the same way, small particles orbiting a star collide, merge, and grow. Repeated slow collisions between small particles form planetesimals, rocky or icy objects as large as a few city blocks. Planetesimals collide and merge again and again, eventually becoming planets like Earth and Pluto. Near the star, rocky planets lacking lighter gases (such as hydrogen) form. In the distant reaches of the system, planets made almost entirely of ice may form.

Once planetesimals reach approximately 60 miles (100 kilometers) in diameter, they become protoplanets. Along their orbits, protoplanets stir up small, leftover planetesimals. These planetesimals move faster and faster as protoplanets grow larger. A cascade of collisions among rapidly moving planetesimals produces a trail of dust grains along each protoplanet's orbit.

Scott Kenyon *is an astronomer at the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts.*



FROM DUST TO DUST describes the evolution of the Kuiper Belt according to computer simulations by author Scott Kenyon and astronomer Ben Bromley. The five figures show the solar nebula from about 3 to 14 billion miles (5 to 23 billion km) away from the Sun (the bright dot in the center of each figure). These are freeze-frames of the region's dustiness — an indication of planet formation — over time. Early on, slow collisions between icy dust particles cause objects to grow slowly, between 0.5 and 5 miles (1 to 8 km) in diameter. Because the gravity of larger objects attracts surrounding matter more quickly, in a few million years, planetesimals measure between about 200 and 600 miles (300 and 1,000 km) across. Finally, the gravity of massive planetesimals stirs up smaller objects, causing them to collide, break apart, and seed the disk with more dust. In this simulation, red represents areas with less dust, while yellow and white signal increasingly greater concentrations of dust (where planets the size of Pluto or larger are forming). Notice how planet formation begins near the Sun and expands outward as time progresses — a result of the fact that objects move faster (and thus collide more often) the closer they are to a star. SCOTT KENYON AND BEN BROMLEY

Eventually, the dust disappears as protoplanets grow into planets.

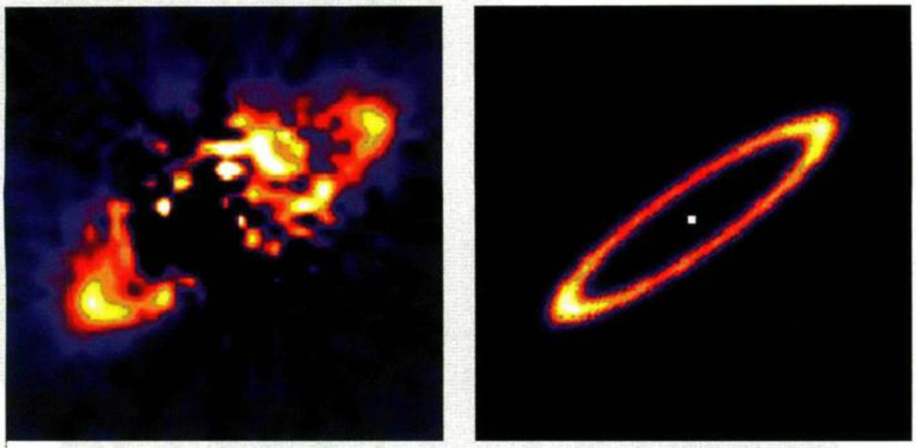
Planet growth from coagulation takes a long time. In your home, a dust bunny grows in a week or so. Planetesimals grow in a few thousand years, and planets can take up to a hundred million years.

Testing the theory

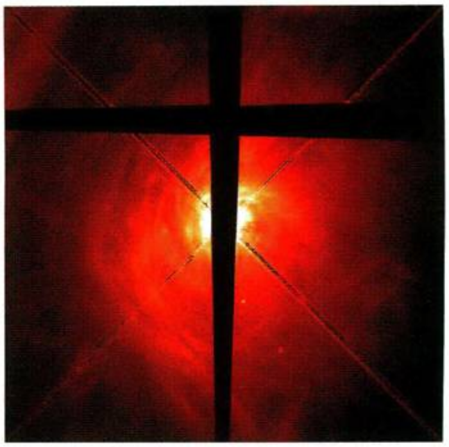
The hypothesis of a planetary system forming from a solar nebula is an attractive explanation for both the orbits of the planets in our solar system and recent observations of gaseous disks around nearby, young stars. Testing the hypothesis is difficult. Because we cannot travel back in time, we do not know how our solar system's planets formed. And while we have detected more than a hundred extrasolar planets, we have yet to catch any forming from a nebula.

Observations spurred our interest in coagulation. In 1992, Jane Luu and David Jewitt of the University of Hawaii discovered the first Kuiper Belt object (KBO). Luu and Jewitt searched for faint, moving, starlike objects among thousands of stationary stars and galaxies.

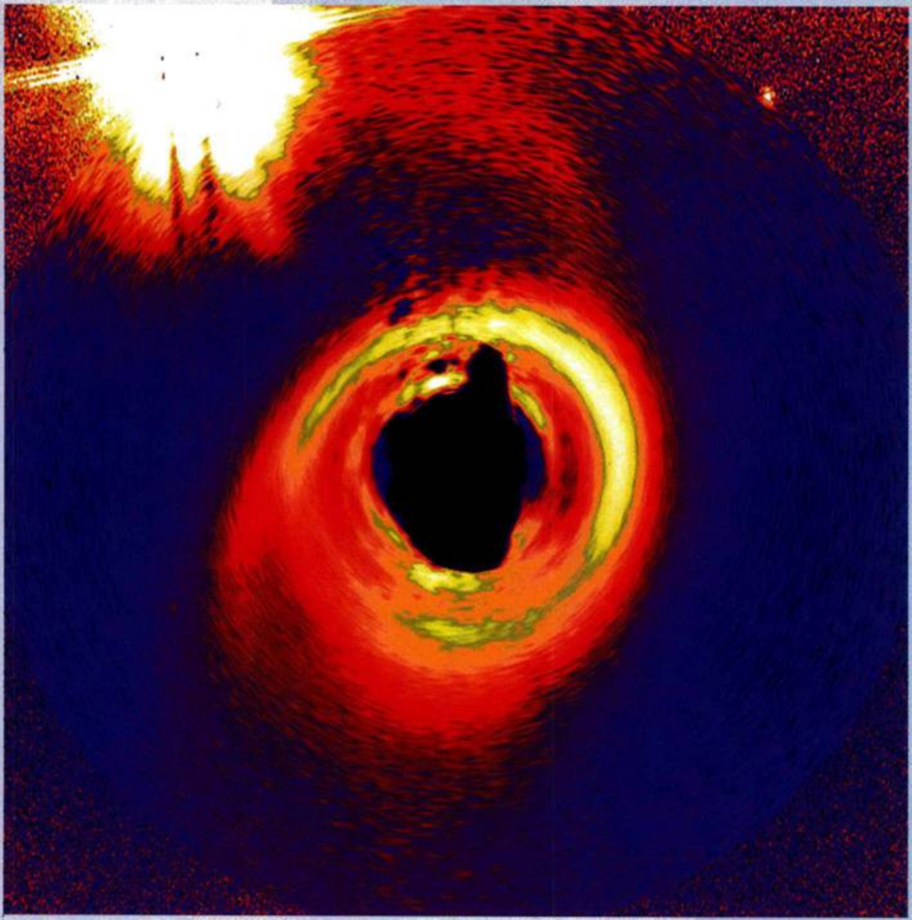
Over the next decade, Luu, Jewitt, and other astronomers found almost a thousand KBOs, icy bodies possibly left over from the initial formation of our planetary system. Lying in a thin belt beyond the orbit of Neptune, KBOs take from two hundred to several thousand years to complete one orbit around the Sun. KBOs are probably similar to Pluto and Charon, which have small cores of iron and rock surrounded by thick layers of ice. A thin atmosphere of nitrogen, methane, and ammonia blankets Pluto; a thinner one may veil Charon.



A RING OF DUST (left) girdles HR 4796A, a star 200 light-years away from Earth. Unseen planets may keep the dust confined to the ring, which was imaged by an infrared camera on the Hubble Space Telescope. (Because the star is so bright relative to the dusty disk's reflected light, a coronagraph was used to block the star's light, so only a dark area is visible.) Compare this image with a computer model of the ring (center), which is a model of our own solar system at a similar stage of evolution. The ring, which may become the Kuiper Belt, is roughly twice the diameter of Pluto's orbit. LEFT: G. SCHNEIDER, ET AL. AND NASA; CENTER: S. KENYON, K. WOOD, B. WHITNEY, AND M. WOLFF

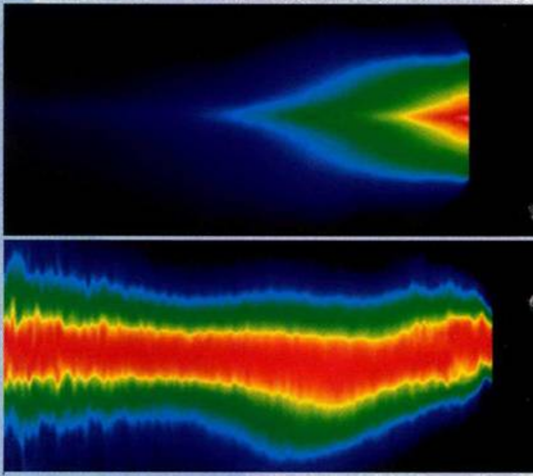


CLUMPS OF GAS AND DUST in the disk around the star AB Aurigae provide the right environment for planet formation. The thick, dark stripes are occulting bars, which are part of the instrumentation used to reduce the glare from the central star. C. A. GRADY, B. WOODGATE, F. BRUHWEILER, A. BOGGESS, P. PLAIT, D. LINDLER, M. CLAMPIN, AND NASA



HD 141569A, a 5 million-year-old star surrounded by a spiral disk of dust, lies 320 light-years away from Earth in the constellation Libra the Scales. HD 141569A was imaged by Hubble in 2002, providing the sharpest picture ever taken of a protoplanetary disk. Because the disk is tilted slightly to our line of sight, astronomers made this colorized version of the disk as seen from above. NASA, M. CLAMPIN, H. FORD, G. ILLINGWORTH, J. KRIST, D. ARDILA, D. GOLIMOWSKI, THE ACS SCIENCE TEAM, AND ESA

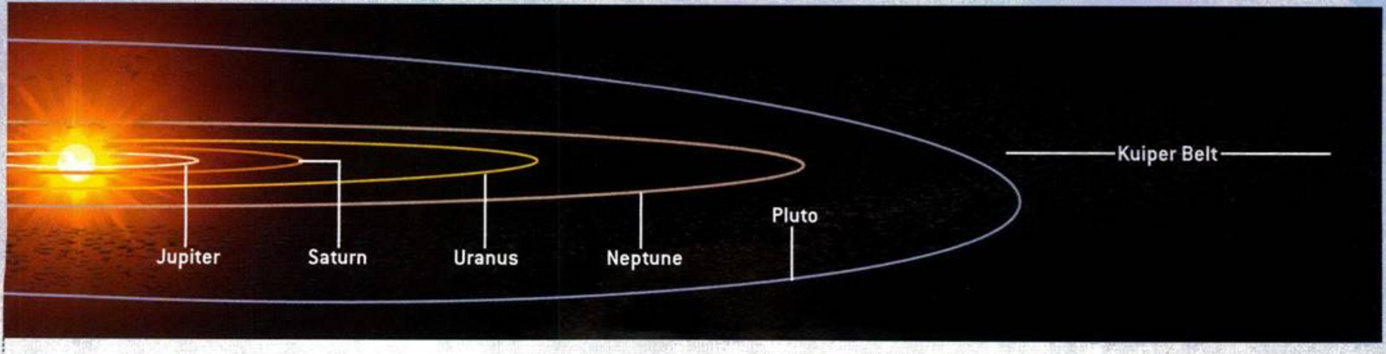
With diameters of more than 600 miles (970 km), several KBOs are almost as large as Pluto, which has a diameter of 1,300 miles (2,100 km). The smallest known KBOs are about 6 miles (10 km) across, but there are probably many more smaller objects (although last year, astronomers searching for 10-mile-wide KBOs turned up just three when their theory predicted sixty, suggesting smaller KBOs may have been pulverized in collisions during the early solar system). These observations of actual solar system objects support the coagulation model, which makes bodies with a range of sizes. If we could use coagulation theory to predict the properties of planets, observations of KBOs might tell us how planets form.



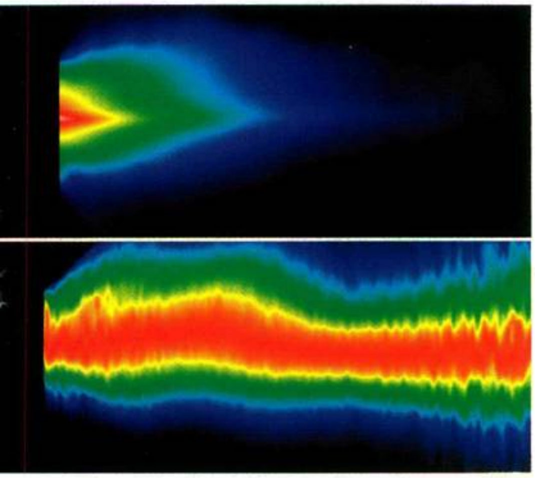
BETA PICTORIS was the first star around which a thin disk of dust was discovered. These images, taken with the Hubble Space Telescope, show a warp in the disk caused by the gravitational tug of either a companion brown dwarf star or by a star passing nearby. The disk is approximately 14 billion miles (22 billion km) in diameter. The bottom image shows a magnified view. STScI

Planets in a computer

To model planet formation on a computer, we begin with a nebula around a Sun-like star. We "seed" the nebula with a billion billion planetesimals, icy rocks 1 meter long that orbit the central star. We program the computer to calculate the number of total collisions, the outcome of each collision, and the gravitational interactions between planetesimals. Within a few weeks, an animation of the agglomeration of planetesimals into planets is created. We vary the starting conditions in our models to see how the masses, numbers, and orbits of the initial seeds influence planet size. With a consortium of 128 interconnected computers, we simulate a large part of a solar system. Someday, we'll simulate an entire solar system.



THE KUIPER BELT is a collection of icy bodies ranging in size from 6 to 600 miles (10 to 1,000 kilometers) in diameter. The distance from Earth to individual Kuiper Belt objects (KBOs) varies from nearly 30 astronomical units (AU, the average Earth–Sun distance), which places the closest KBOs just outside Neptune's orbit, to more than 70 AU, which is nearly twice the average distance between Pluto and the Sun. *ASTRONOMY:* JAY SMITH



In our simulations, shortly after the Sun forms, planetesimals collide rarely and grow slowly. But once they become 6 miles (10 km) across, their gravity attracts nearby objects, and they grow faster and faster. The largest objects grow rapidly, becoming full-fledged planets in a few million years or less — an astronomical blink of an eye.

Along their orbits, young planets stir up leftover planetesimals that collide and break apart. Countless collisions produce clouds of dusty ice grains — some of which may be similar to the snow crystals Wilson Bentley photographed. As planets grow, more collisions produce more dust. By the time a planet like Pluto forms — between 10 and 50 million years after the process starts — almost all planetesimals around it have been ground into a ring of icy grains. Over time, the ring slowly disperses as Pluto and other planets sweep up most of the snowflakes; the remainder are dispersed by solar wind.

Planet formation begins in the inner part of the solar nebula, where the concentration of planetesimals is largest. Because objects closer to the Sun move faster than objects farther out, collisions occur more frequently near the Sun, promoting the rapid growth of objects. Calculations indicate a planet like Earth forms in 1 to 10 million years, and one like Neptune takes 30 million years or longer.

Neptune, the outermost gas giant in our solar system, is 17 times more massive than Earth. Once Neptune formed, its gravity stirred up planetesimals that were trying to form new planets in the outer solar system. This gravitational interaction was so severe that large planets could not form. Pluto may be the largest planet possible in the outer solar system, the area beyond the orbit of Neptune.

Theories are tested by comparing their predictions with observations. Using instruments like the Hubble Space Telescope, observers count large and small KBOs. There appear to be 100,000 small KBOs (diameters between 60 and 300 miles [100 and 480 km]) and 500 KBOs larger than 300 miles across. Our models predict 200,000 small KBOs and 600 to 2,000 large KBOs; these numbers agree well enough with observations to give us confidence that our theory describes what happened 4.5 billion years ago, 4 billion miles away from Earth.

Our theory also predicts dusty rings around stars after planets form. When a planet has just formed, its orbit contains dust grains. Because the grains reflect light from the central star, a ring of starlit material marks the planet's orbit, a telltale sign of recent planet formation. Some nearby stars, including Vega and HR 4796A, have such dusty rings, but astronomers have yet to confirm how these rings formed.

Travels to the Kuiper Belt

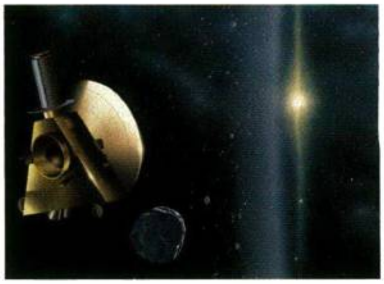
Several groups of U.S. scientists are involved in plans to construct large, ground-based telescopes with dishes 65 to 100 feet (20 to 30 meters) across. The European Southern Observatory has ambitious plans for the OverWhelmingly Large (OWL) telescope, which will contain a mosaic of 26-foot (8m) mirrors spanning 330 feet (100m). If OWL passes the hurdles of funding and site selection, it will revolutionize planetary astronomy. Planned for completion in 2015, the OWL telescope will have the resolution to read the date on a quarter 150 miles (240 km) away. Sensitive cameras attached to this telescope will be able to image the dusty rings of terrestrial planets now forming in the Orion Nebula and record images of the dusty remains of icy planet formation similar to the Kuiper Belt in our solar system. OWL hopes to reveal that solar systems like our own are common.

We may get the best view yet of our own outer solar system with NASA's New Horizons mission, which is due to launch in 2006. In 2015, it's expected to fly by Pluto and Charon before traveling outward to explore several KBOs. We may find rocky islands embedded in oceans of ice. Onboard instruments will reveal the composition of both the ice and any atmosphere. Undoubtedly, New Horizons will raise (and hopefully answer) questions astronomers have yet to ask.

/// THE FUTURE OF KBOs

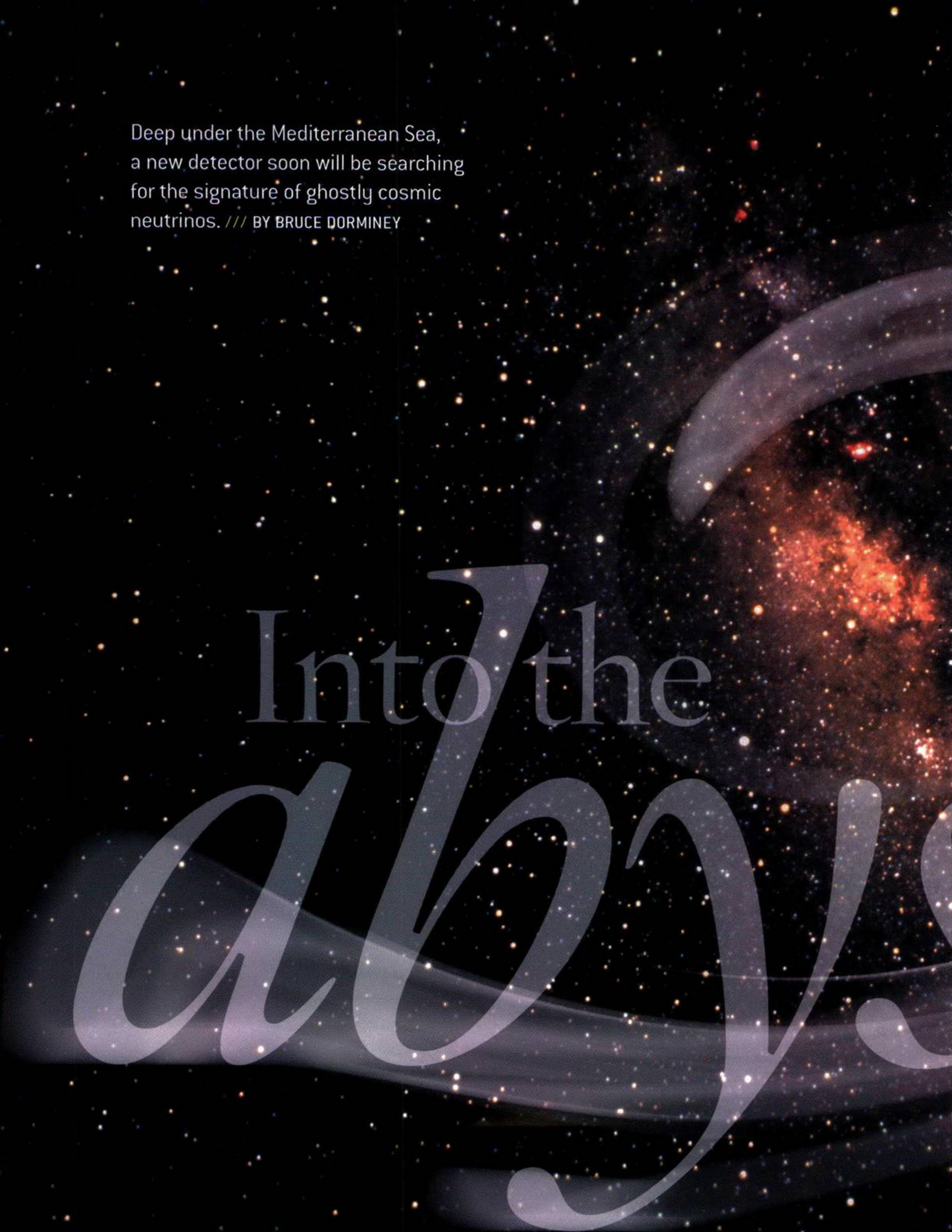
NASA

THE OVERWHELMINGLY LARGE (OWL) telescope (above) is a current proposal of the European Southern Observatory. Operating in visual and near-infrared wavelengths, the OWL telescope will have milliarcsecond resolution and a limiting magnitude of 38. Astronomers, however, will be doing more than observing from Earth; some dream of encountering a KBO. This artist's illustration (below) shows NASA's New Horizons spacecraft close to a Kuiper Belt object. The Sun, more than 4 billion miles (6.7 billion km) away, shines as a bright star embedded in the glow of our solar system's dust lane. Jupiter (orange) and Neptune (blue) are visible below the Sun. No other KBOs would be seen, but several are shown to give the impression of an extensive disk of icy worlds beyond Neptune.


NASA

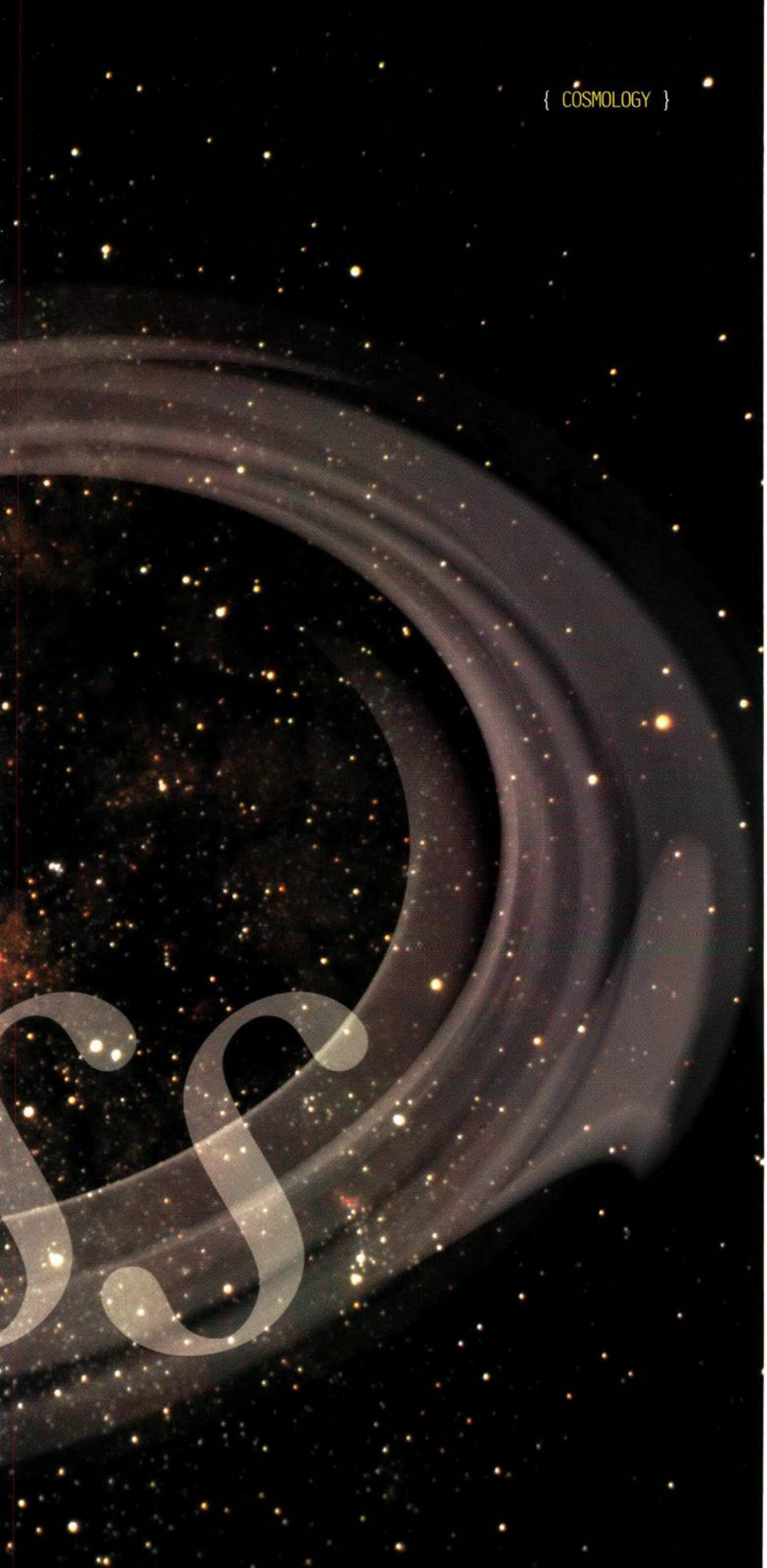
Science progresses by assuming events we observe on Earth occur elsewhere in the universe and the physical laws we discover apply to every solar system in every galaxy. This approach led to the discovery of the Kuiper Belt and the first extrasolar planets. Extrasolar planets changed our understanding of planet formation. The thrilling and humbling detection of the first Earth-like extrasolar planet may change our understanding of ourselves. ■

To learn more about KBOs and planet formation, visit www.astronomy.com/toc



Into the abys

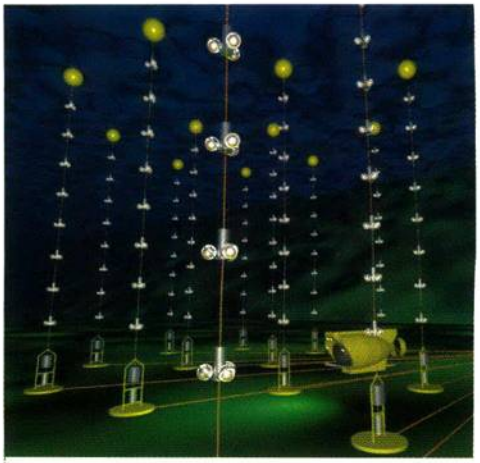
Deep under the Mediterranean Sea, a new detector soon will be searching for the signature of ghostly cosmic neutrinos. /// BY BRUCE DORMINEY



ALMOST EVERYTHING WE KNOW about the universe comes to us from observations of photons. From the lowest-energy radio waves to the highest-energy gamma rays — including the visible light so near and dear to humans — photons carry invaluable information to astronomers seeking to understand the cosmos. Yet the gas and dust that pervade space often hinder our view of photons emanating from the most interesting objects.

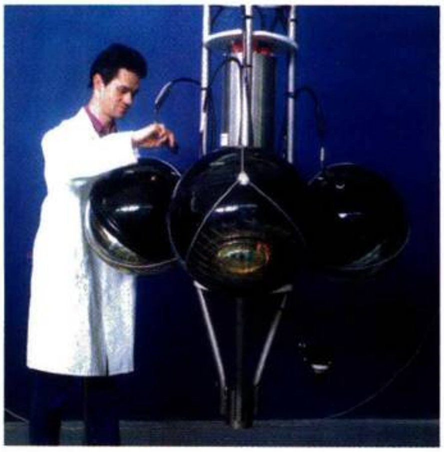
What scientists need is a particle that remains unaffected by gas, dust, and the ubiquitous magnetic fields it encounters as it journeys through space. The neutrino could be the ideal candidate. It interacts with matter so rarely that it travels virtually unimpeded straight from its source at nearly the speed of light. Neutrinos offer scientists the chance to probe the Sun's interior, supernova explosions, gamma-ray bursts, the cores of active galaxies — and even the birth of the universe itself.

To most people, the word *observatory* conjures up images of sleek domes at the summits of far-flung mountaintops. Yet neutrino observatories turn this picture on its head. Because their detectors must be shielded against charged-particle pollution from cosmic-ray interactions in Earth's own atmosphere, they often are placed deep underground, under water, or buried in ice. Since neutrino astronomy's beginnings four decades ago, detectors have been installed in mines, under mountains,



THE MILKY WAY [left] and the supermassive black hole at its center will be prime regions of study when ANTARES, an underwater neutrino telescope located off France's southern coast [above], comes on-line. The galaxy's core lies in the dark dust cloud just right of the central star cloud in the visible-light image. DAVID TALENT/NOAO/AURA/NSF; ANTARES COLLABORATION/F. MONTANET

PHOTOMULTIPLIERS IN ANTARES will detect Cerenkov radiation from muons produced when a neutrino interacts with either the seabed or surrounding seawater. ANTARES COLLABORATION/CEA/DSM/DAPNIA



A TRIO OF PHOTOMULTIPLIERS makes up one "story" on a line of the ANTARES neutrino detector. The photomultipliers point down at a 45° angle because they seek neutrinos that have passed through Earth. ANTARES COLLABORATION/CAMILLE MOIRENC

DEPLOYING A JUNCTION BOX from the deck of the good ship *Castor*, scientists start to assemble the ANTARES telescope in the Mediterranean Sea off the southern coast of France. ANTARES COLLABORATION/CNRS DARS/PAPILLAULT

under tons of Antarctic ice, in the world's deepest lake, and now, on the floor of the Mediterranean Sea in a restricted naval zone better known for the comings and goings of France's submarine fleet than particle physicists.

Under the Mediterranean

The ANTARES project soon will become the first large-scale, deep-sea neutrino telescope in the world. This approximately $20 million joint European-Russian venture is already under construction 23 miles (37 kilometers) off the coast of Toulon in the south of France. ANTARES — an acronym for Astronomy with a Neutrino Telescope and Abyss environmental RESearch — will go into full operation in 2005 at a depth of 1.5 miles (2.4 km).

When complete, the ANTARES array will be taller than the Eiffel Tower.

The telescope will be on the lookout for muon neutrinos. One of three varieties of neutrino, this one is associated with the subatomic particle known as a muon. (Muons basically are heavy electrons; they possess the same spin and negative charge as electrons but have 207 times the mass.)

When a muon neutrino strikes a proton inside an atomic nucleus, the interaction creates a muon. This doesn't happen often: The chances of a direct hit are about one in one billion trillion trillion. In those extremely rare circumstances, the very high-energy neutrino produces a muon traveling at close to the speed of light in a vacuum — easily outpacing the speed of light in water. (Light traverses water at 140,000 miles per second, three-quarters of its speed in a vacuum.) The muon emits an optical shock wave of blue light known as Cerenkov radiation, the optical equivalent of a sonic boom.

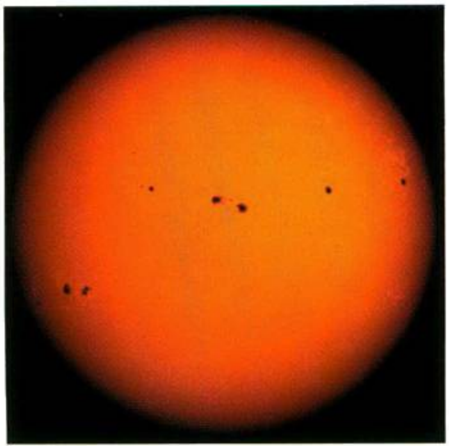
ANTARES consists of twelve vertical strings each loaded with 90 light-sensitive photomultipliers. The array will search for the telltale signature of Cerenkov radiation in 350 million cubic feet (10 million cubic meters) of Mediterranean seawater. Interestingly, the photomultipliers face the seafloor at a 45° angle because scientists want to find only neutrinos rising from below, not those coming from the sky above. Neutrinos so rarely interact with matter that even 8,000 miles of solid Earth poses no barrier. ANTARES seeks Cerenkov radiation from muons emitted by extraordinarily rare neutrino interactions with either the rocky seabed or surrounding seawater. The detectors also face down and lie under thousands of feet of water in order to lower the background noise. Cosmic rays hitting molecules at the top of Earth's atmosphere also produce muons — and these muons outnumber neutrino-induced muons by a factor of 100,000.

ANTARES will reconstruct the direction of any incoming muon — almost exactly the same as the direction of the parent neutrino — by recording which photomultipliers detect Cerenkov light at what precise time. The telescope can pinpoint the direction of the neutrino to within about one-third of a degree, an angular resolution good enough to detect a globular cluster through a conventional optical telescope.

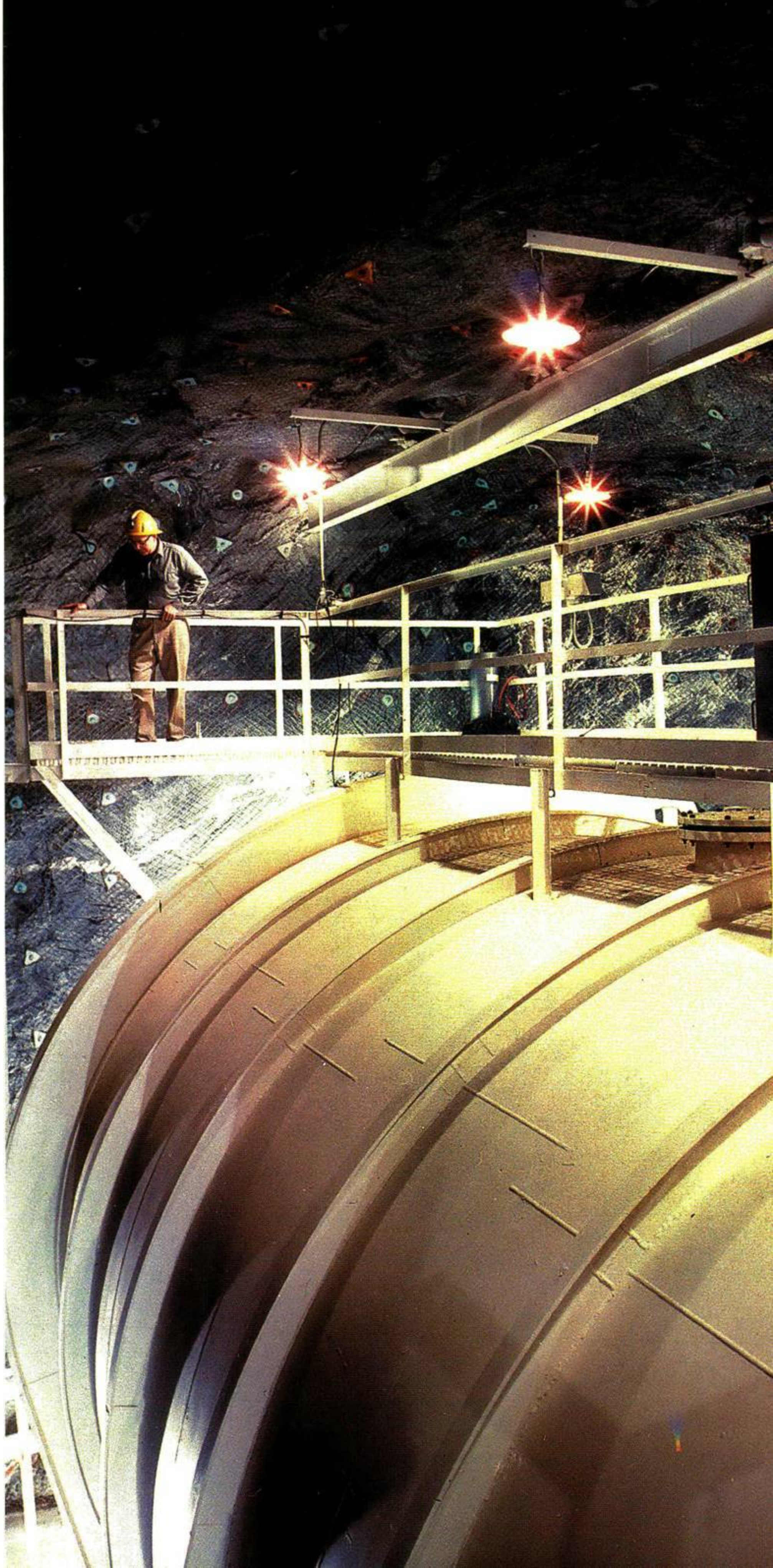
At any given time, ANTARES will have an unobstructed view of slightly more than 50 percent of the celestial sphere. During the course of a year, the telescope's field of view will sweep out most of the sky. (From its latitude at 43° north, ANTARES will miss only those regions north of declination 47°.) Of particular interest, ANTARES will clearly see the center of our galaxy more than two-thirds of the time. In contrast, its counterparts buried in ice at the South Pole always point to the same part of the sky and never see the galactic center.

When everything is up and operating, scientists will be able to track and analyze events in real time on computer screens

Bruce Dorminey *is a France-based science writer and author of* Distant Wanderers: The Search for Planets Beyond the Solar System *(Springer-Verlag).*



THE SUN (above) was the first object from which neutrinos were detected. The discovery came from a detector containing 100,000 gallons of dry-cleaning fluid (right) buried in a gold mine. NSO/AURA/NSF; BROOKHAVEN NATIONAL LABORATORY



from offices in Marseille's Center for Particle Physics (CPPM), some 60 miles (100 km) away from the underwater site. A 28-mile-long (45 km) fiber-optic cable already connects ANTARES to the shore, but for now, researchers have to be content with real-time readings of the sea's ambient temperature and humidity.

Scouring the seafloor

Site surveys using both submersibles and submarines began in 1996. The ANTARES team scoured about 10 million square feet (1 square kilometer), working around dead trees, an 18th-century cannon, a pallet of paint cans, and even a piece of World War II ordnance. But John Carr, a particle physicist at CPPM and spokesman for the project, says they avoided such obstacles by using a specially equipped boat on the surface and a sonar acoustic positioning system on the seafloor. When complete, the array will be taller than the Eiffel Tower and resemble a stretched hexagon: 490 feet (150 meters) wide and 1,510 feet (460 meters) from the seafloor to the top of each line's underwater buoy.

The science of this estimated 10-year experiment relies on the great sensitivity and durability of the photomultipliers, which are housed in 0.8-inch-thick (2 cm) glass spheres designed to withstand undersea pressures of at least 250 atmospheres. Sturdy as the equipment may be, everything is subject to a certain amount of sway, not unlike kelp caught in an undersea eddy. Just as an observational astronomer on a mountaintop must know the precise

SUPERNOVA 1987A (the bright star with diffraction spikes at right) in the Large Magellanic Cloud was the second celestial object — and so far the last — seen to emit neutrinos. The spidery Tarantula Nebula sits at the upper left of this image. MARCELO BASS, CTIO/NOAO/AURA/NSF

position of the telescope, the ANTARES team must consider each individual line's inherent sway. Thus, six hydrophones on each line will calibrate exactly where the line lies within the array as a whole. Only by knowing each line's precise position can scientists pinpoint where on the celestial sphere the neutrinos originated.

Not all the light reaching ANTARES will be astronomical signals, however. Cerenkov radiation from the radioactive decay of potassium-40 in ordinary sea salt and bioluminescence from deep-sea marine life could be mistaken for radiation caused by incoming muons. Potassium decay can generate thousands of flashes of blue light at such depths, while an enzyme in deep-sea plankton causes blue flashes that marine biologists think might be used for swarming and sexual attraction.

Gabriel Gorsky, a marine ecologist at France's Oceanologic Observatory in Villefranche sur Mer who helped survey the site in a deep-sea submersible, says the plankton's mere movements at such depths trigger bioluminescent "blue fireworks." But as Carr points out, neither potassium decay nor bioluminescence produces light with a coherent velocity like that of a Cerenkov shock wave caused by an incoming muon. The shock wave will trigger a minimum of eight different photomultiplier modules, and scientists will be able to verify its muon origin by timing the shock wave as it passes each module.

While the ANTARES team hopes to detect such incursions regularly — from both galactic and extragalactic sources such as X-ray binaries, active galactic nuclei, and possibly exotic forms of dark matter — uncertainty abounds. Neutrino astronomy remains in its infancy. It's been a scant 75 years since Wolfgang Pauli predicted the existence of the particle that later was termed the neutrino.

By the late 1950s, scientists began to discuss neutrino astronomy in earnest. But it took another decade before Brookhaven National Laboratory chemist Raymond Davis, Jr., led a team that, in 1968, detected neutrinos produced by fusion reactions in the Sun. Davis's detector was a tank containing 100,000 gallons of perchloroethylene (essentially dry-cleaning fluid) located in the Homestake Gold Mine in Lead, South Dakota. Another twenty years passed before two separate teams operating detectors in the United States and Japan captured a total of 19 neutrinos in a 13-second burst from the collapsing core of the star that triggered Supernova 1987A

/// A BIG, FAT, GREEK OBSERVATORY

A SECOND, complementary deep-sea neutrino observatory is under construction in the Mediterranean Sea. The $10 million, Greek-led NESTOR project will boast a depth of 2.5 miles (4.1 km), nearly double that of ANTARES. Short for the Neutrino Extended Submarine Telescope with Oceanographic Research, NESTOR expects to be sensitive to many of the same celestial sources that ANTARES will be targeting. But NESTOR plans a unique triangular configuration.

Operating on a large undersea abyssal plain some 9 miles (14 km) southwest of Greece's Peloponnese peninsula, its center will consist of a 1,000-foot-long (300 meters) tower made up of 12 hexagonal floors, with 12 photomultipliers per floor. Three additional vertical strings with 22 photomultipliers each will be placed within 260 feet (80 meters) of the central tower. The tower floor is in place already, along with the budding observatory's junction box and fiber-optic cable link to shore, even though the tower itself won't be completed for another two to three years.

University of Athens particle physicist and NESTOR spokesman Leo Resvanis is convinced NESTOR's additional depth will give it the ability to more easily filter out unwanted muons created by incoming cosmic rays interacting with Earth's atmosphere. As Resvanis puts it, NESTOR is merely a contemporary attempt to do what his Greek predecessors did two thousand years ago. While they used the sides of ordinary water wells to augment their study of the heavens, he and his colleagues must use millions of tons of seawater. "In a field where the signal is controlled by nature," said Resvanis, "the name of the game is signal to noise. And we can only work on the noise."

in the Large Magellanic Cloud. Ironically, both underground detectors were built to look for the predicted decay of protons, not to find celestial sources of neutrinos.

Yet after four decades of looking for astronomical neutrinos, only these two sources have been confirmed: low-energy neutrinos from our Sun and intermediate-energy neutrinos from Supernova 1987A. So, even though theorists remain sanguine about detecting neutrinos from all manner of sources, no one, including advocates of present and future neutrino observatories, can say that any of these observatories will find new sources.

SAGITTARIUS A*, the bright X-ray source (arrow) in this image from Chandra, should emit prodigious amounts of neutrinos. Scientists hope to detect many of these neutrinos with ANTARES, which will point toward the galaxy's center more than two-thirds of the time. NASA/CXC/MIT/F. K. BAGANOFF, ET AL.

Searching for dark matter

To a large extent, ANTARES and other large-scale neutrino projects are driven by the prospect of indirectly detecting hypothetical forms of dark matter — in our Sun, in the galaxy's center, and even in the center of Earth. Results from the Wilkinson Microwave Anisotropy Probe's survey of the cosmic microwave background show that dark matter makes up as much as 23 percent of the universe. A large portion may exist as exotic Weakly Interacting Massive Particles, or WIMPs for short, a still-hypothetical form of matter thought to be a relic of the Big Bang. WIMPs share the neutrino's ability to avoid interaction with matter but have masses far greater. Their high mass causes them to collect in any large gravitational well.

Carr believes the geographic location of ANTARES may allow it to detect a large neutrino flux from just beyond the event horizon of Sagittarius A*, the supermassive black hole that lurks at the center of our galaxy. However, Venya Berezinsky, a particle physicist at Italy's Gran Sasso National Laboratory, says his group already has looked for a gamma-ray signal from WIMPs in the galactic center and found nothing. He reasons that if WIMPS in the galaxy's core are not detectable in gamma rays, it's doubtful they would be detectable in neutrinos.

To a large extent, ANTARES is driven by the prospect of indirectly detecting hypothetical forms of dark matter.

Others simply think ANTARES and similar projects have "overhyped" their ability to detect WIMPs. University of Hawaii particle physicist John Learned says that because WIMPs would produce neutrinos at relatively low energies, they would fly under ANTARES's high-energy neutrino radar.

But WIMPs hardly represent the neutrino endgame. Neutrino astronomy will find its Holy Grail only many decades from now, when someone finds a way to detect the cosmic neutrino background, or CNB, the extraordinarily low-energy neutrino analog of the microwave background. Learned notes that detecting the CNB would "put a lid on any qualms about the Big Bang theory." It also would offer a direct probe of the universe at its birth some 13.7 billion years ago.

"With the microwave background, we are looking at the universe about 380,000 years after the Big Bang," says Princeton University cosmologist David Spergel. "We really can't see structure on scales smaller than one-sixth of a degree. With the CNB, small-scale neutrino fluctuations would be as easy to detect as large-scale neutrino fluctuations, so we would learn a lot about inflation and how lumpy the universe is as a function of scale. That would tell us about the initial conditions for galaxy formation."

"The cosmic neutrino background would be a whole new window onto the early universe," says Spergel. "People fantasize about it, but it's not something they think about detecting during their own careers." ◼

To learn more about current searches for neutrinos, visit www.astronomy.com/toc

BY MARTIN RATCLIFFE AND ALISTER LING

MARCH 04

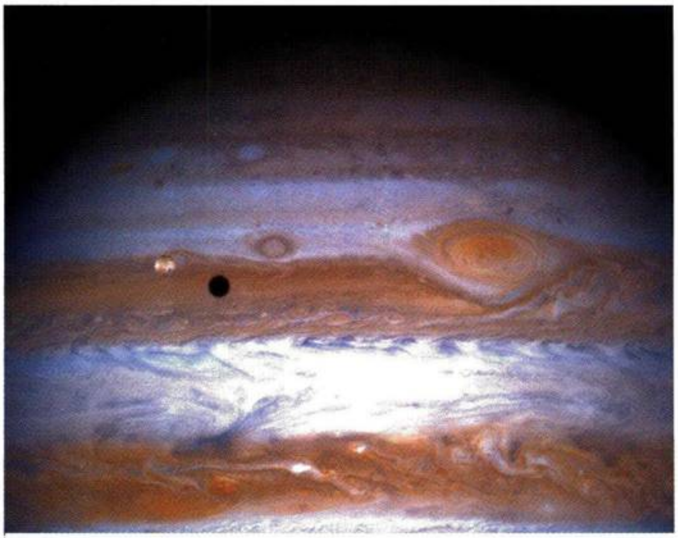
A parade of five bright planets spans the evening sky this month, punctuated by brilliant Venus in the west and Jupiter at its peak in the east.

A five-planet cornucopia

March lets you see all five planets known to the ancients in one sweep across the evening sky. Our ancestors would have been impressed by this display of "wandering gods" in the heavens. Thanks to science, we don't have to fear these apparitions — we can appreciate their beauty as well as understand what these points of light really are.

A look to the west during twilight immediately reveals Venus. Clouds completely enshroud the surface of Venus, reflecting more sunlight than any other planet. In fact, Venus shines so brightly that it can cast a shadow at a dark site. Through a small telescope, you can watch its gibbous shape thin to half-lit by the end of March. Although Venus may be a fraternal twin of Earth in size and mass, its crushing, Sun-baked atmosphere makes it completely inhospitable.

To the upper left of Venus lies ruddy Mars. Compare it with the red giant star Aldebaran, a little farther up the line. It too claims redness in its mythological past — Aldebaran represents the red eye of Taurus the Bull, although it looks no more red than Mars. The two appear quite similar in brightness and color, but you usually can tell them apart because Mars doesn't twinkle like a star unless Earth's atmosphere is abnormally turbulent. Seen through a telescope, the Red Planet appears disappointingly small. Keep your eyes on Mars as it cruises south of the Pleiades star cluster from March 18 to 20.



JUPITER REACHES ITS PEAK in March, when observers will get great looks (although less impressive than this Cassini photo) at its intricate cloud patterns. On March 27/28, three moons will cast their shadows on the disk simultaneously, tripling the action seen here. NASA/JPL/UNIVERSITY OF ARIZONA

Yellow Saturn comes next in line, riding high above mighty Orion. The disk casts a noticeable shadow onto the rings this month, enhancing the planet's charming three-dimensional appearance.

Low in the east as darkness falls, bright Jupiter climbs higher as evening progresses. The king of planets arrives at opposition, the point in our sky opposite the Sun, on March 3/4. Three nights later, the Moon hits its opposition, better known as Full Moon, next to Jupiter. A triple shadow transit, in which the shadows of three moons simultaneously fall on Jupiter's cloudtops, tops the bill late Saturday night, March 27/28. Several double shadow transits occur this month, so everyone around the globe will have a chance to view a consolation prize.

Mercury joins the parade after midmonth. Because this is its best evening show of the year for northern observers, the planet will be a snap to find. Early in the apparition, around March 15, you'll need binoculars to pull Mercury out of the bright twilight glow. But by the 20th, it becomes quite obvious to the naked eye.

The icing on this celestial cake is the nightly sweep of the Moon along the planetary lineup. It starts on March 21, when a wafer-thin, 1-day-old crescent lies below Mercury. Can you pick out the Moon without binoculars? A spectacular conjunction between the Moon and Venus is set for the 24th, followed one night later by a Moon-Mars-Pleiades grouping.

Comet C/2002 T7 should be an easy target for binoculars early this month as it hangs low in the western sky about an hour after sunset. It slumps out of sight after mid-March but will reappear low in the morning sky by mid-April. If predictions hold, it should be a bright, 3rd-magnitude fuzzball sporting a nice tail by then.

We've added a new dimension to our NexStar® GPS family of GoTo telescopes.

NexStar 11 GPS

NexStar 9.25 GPS**

NexStar 8 GPS

NOW AVAILABLE WITH
StarBright® XLT
HIGH PERFORMANCE OPTICAL SYSTEM
For more information, visit: www.celestron.com/starbrightxlt

Introducing the NexStar 9.25 GPS.

The Celestron 9.25" optical tube was already a favorite among astrophotographers and discerning visual observers, but now with the **carbon fiber tube** and the **NexStar GPS mount**, it is a formidable addition to the NexStar GPS family. The 9.25 was **specifically designed for visual infinity focus when using 2" eyepieces** and has an **optimized baffle system** to benefit astrophotography by minimizing vignetting at the edge of the field of view. Its **longer primary focal length** and **lower magnification secondary mirror** contribute to a flatter field of view at the focal plane and helps to further reduce optical aberrations. ***This feature-packed model comes standard with a carbon fiber tube and Celestron's renowned StarBright® multi-coatings***. The NexStar 9.25 GPS is compatible with the complete line of Celestron photographic and visual accessories.

What makes the NexStar 9.25 GPS great for astrophotography?

- **Longer focal length primary and lower magnification secondary** — Contributes to a flatter focal plane with less coma and off-axis astigmatism.
- **Baffle design** — Optimized for astrophotography. Minimizes vignetting at the edge of the field of view. This reduces light drop off at the corners of your film plane.

NexStar GPS. Quality that's designed in — not added on.

NexStar GPS Standard Software Features:

- **GPS Align** – Press the Align button and the telescope will automatically begin its alignment sequence.
- **Database** – 40,000 + objects in database.
- **Magnetic North Compass Compensation** – Magnetic north and true north are not the same; magnetic north varies depending upon your position on the earth. The NexStar allows you to compensate for the variation. This improves pointing during the automated GPS alignment process.
- **Quick Align** – Gets the telescope tracking the sky without actually aligning it to two stars. Useful for tracking planets or solar observing.
- **EQ Auto Align** – The telescope will automatically pick and slew to your alignment stars even in equatorial mode.
- **Polar Alignment Routine** –The NexStar has a polar alignment algorithm making polar alignment easy and accurate for equatorial use.
- **User-defined Filter Limits** – When filter limit is set, the hand control will only display objects above the horizon or as set by the user.
- **User defined Slew Limits** – Set the maximum and minimum slew limits on the altitude axis.

Quality Components:

- Pittman Lo-Cog® brush commutated DC motors; made in U.S.A.
- 32-pitch, 5.625" pitch diameter, 180-tooth Bronze gear.
- Stainless steel worm shaft.
- Precision annealed Pyrex primary and secondary mirrors.
- **Carbon Fiber Tube** –1/4 the thermal expansion of aluminum; creates a more stable focus. The tube is four times more resistant to temperature changes than aluminum tubes; minimizes your need to re-focus.

Intelligent Design:

- Built-in 16-channel GPS receiver, magnetic compass and internal altitude switch work together to fully automate the alignment process.
- **Internal Slip Ring** – Eliminates power cable wrapping.
- **Auxiliary ports are located on the rotating base** – Auxiliary port rotates with the telescope; vastly improves cable management.
- **Ergonomic design** - Carrying handles strategically placed for improved lifting power and stability; hand control integrated in fork arm for ease of use whether on the scope or in your hand.
- **Optical Tube Assembly Mounting Rails** – An outer rail on each side of the optical tube provides rigid, flex-free movement.
- **Unique roller bearing and shaft design** – The telescope base rotates around a wide 9.5" track for maximum stability; especially important when equatorially mounted for imaging.

Standard Equipment & Specifications

	NexStar 8 GPS	NexStar 9.25 GPS	NexStar 11 GPS
Eyepiece	1.25" 40mm Plössl (51x)	1.25" 40mm Plössl (59x)	1.25" 40mm Plössl (70x)
Finderscope	9x50	9x50	9x50
AC Adapter***	Included	Included	*Included*
Tripod	Heavy-Duty Adjustable	Heavy-Duty Adjustable	Heavy-Duty Adjustable
Fastar Compatible	Yes	No	Yes
Mirror Coatings	StarBright®, 5-step multi-layer	StarBright®, 5-step multi-layer	StarBright®, 5-step multi-layer
Telescope Weight	42 lbs	58 lbs	65 lbs.
Price*	**$1999**	**$2699**	**$2999**
Shipping & Handling	$95	$115	$125

NEW 2003 PRODUCT GUIDE

To request a copy of Celestron's new 2003 Product Guide, contact us at (310) 328-9560.

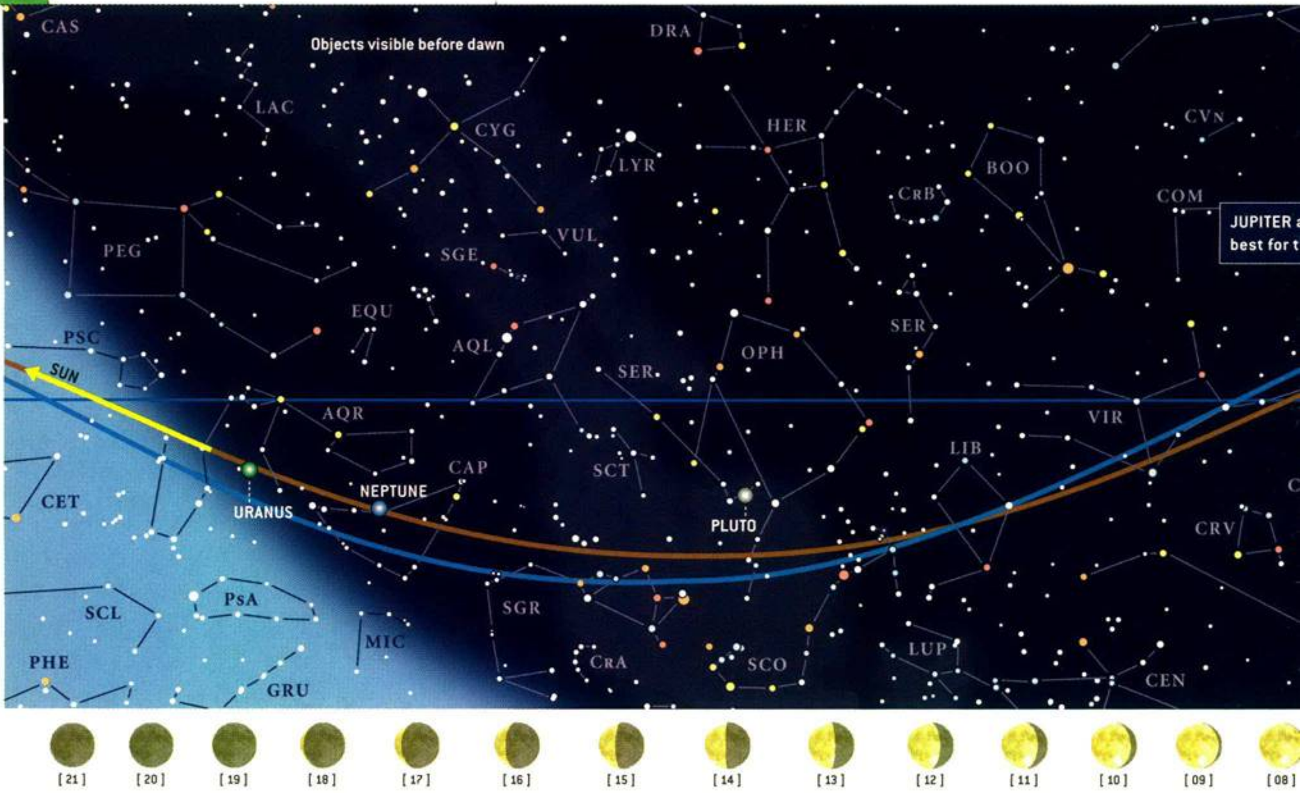
CELESTRON®

2835 Columbia St. • Torrance, CA 90503 U.S.A.• Tel: 310.328.9560 • **www.celestron.com**

©2003 Celestron NexStar and StarBright are registered trademarks of Celestron. Product design and specifications subject to change without notice. *Prices shown are retail mail-order and shown in U.S. Dollars.
**NexStar 9.25 GPS shown with these optional accessories: Equatorial Wedge (#93655), Radial Guider (94176), and MicroGuide Reticle Eyepiece (#94171). Camera not included. ***120V AC Adapter included for U.S.A. and Canada only.

Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and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Objects visible before dawn
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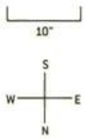
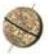
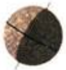
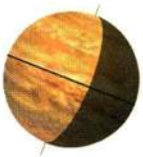
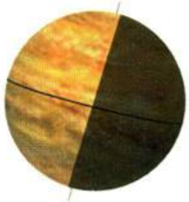
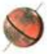
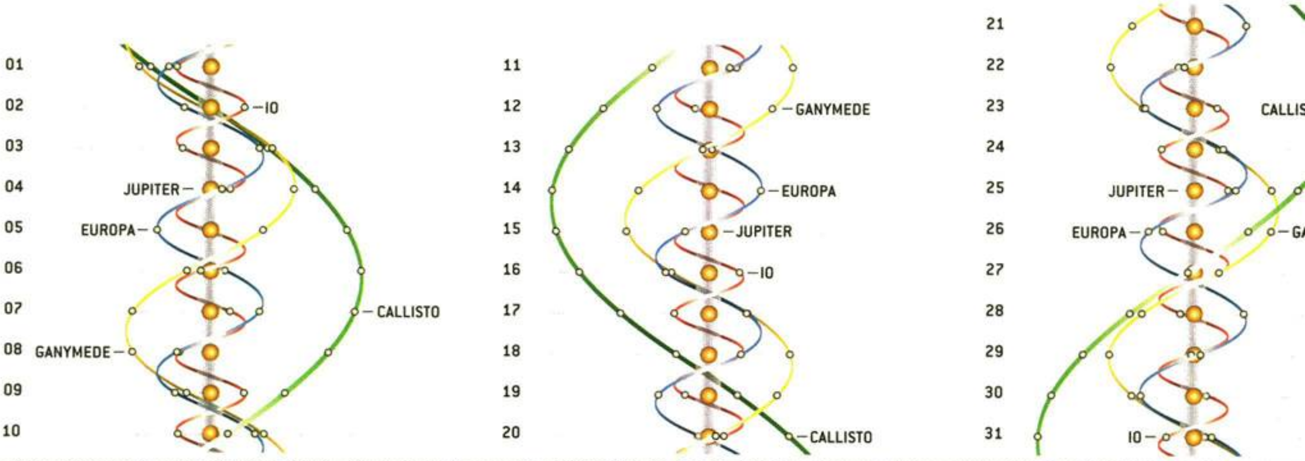
To locate the Moon in the sky, draw a line from the phase shown for the day s



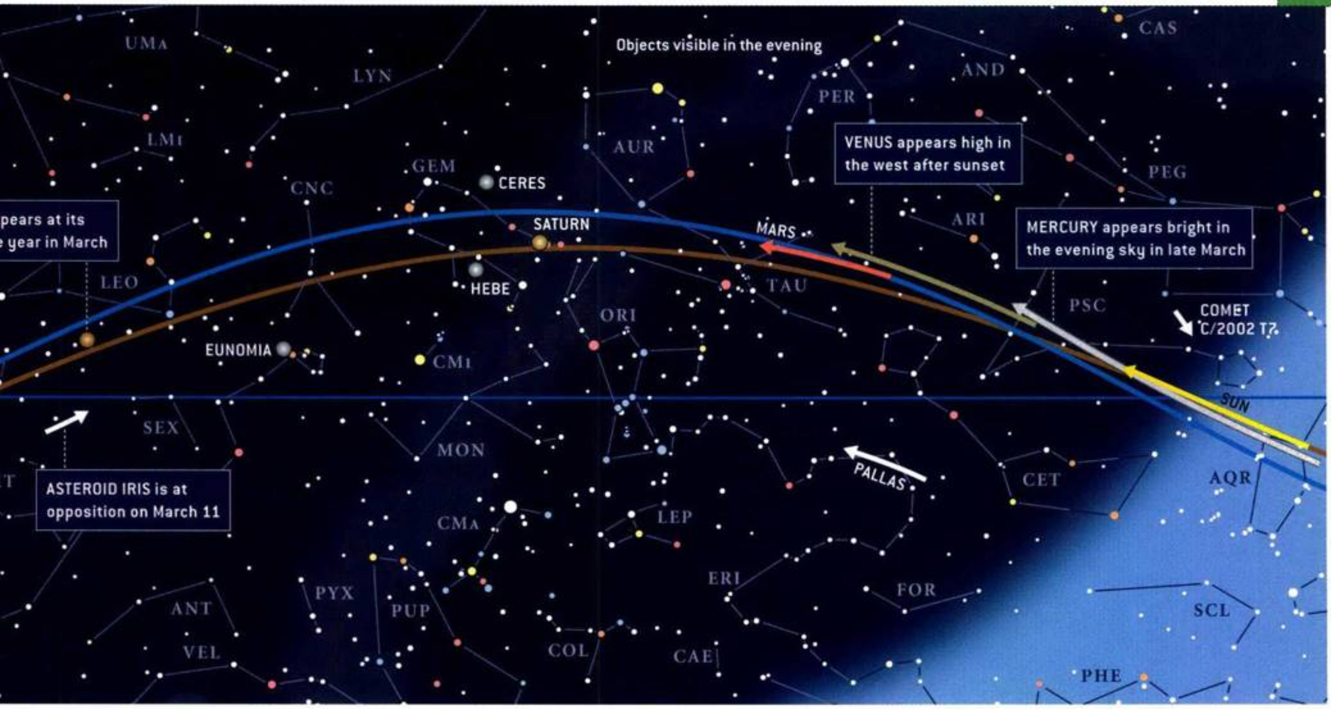
PLANETS	 MERCURY	 MERCURY	 VENUS	 VENUS	 MARS
Date	March 15	March 31	March 1	March 31	March 1
Magnitude	–1.4	0.2	–4.2	–4.4	1.3
Angular Size	5.4"	7.9"	18.0"	23.9"	5.3"
Illumination	91%	36%	65%	50%	92%
Distance (AU) from Earth	1.243	0.852	0.925	0.699	1.784
Distance (AU) from Sun	0.319	0.335	0.719	0.719	1.569
Right Ascension (2000.0)	0h18.9m	1h44.3m	1h29.8m	3h33.4m	3h33.2
Declination (2000.0)	1°43'	13°44'	10°25'	22°33'	20°15'

Jupiter's moons

Dots display positions of Galilean satellites at 11 P.M. EST on date shown. South is at top to match the view in a telescope



colored dots show motions and locations of solar system objects during the month.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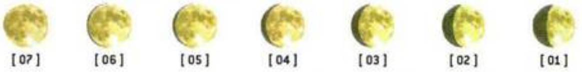
Objects visible in the evening

pears at its
e year in March

ASTEROID IRIS is at opposition on March 11

VENUS appears high in the west after sunset

MERCURY appears bright in the evening sky in late March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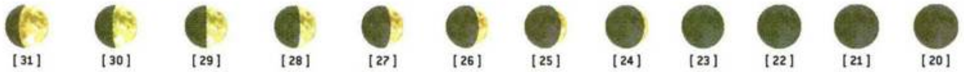
aight up to the curved blue line.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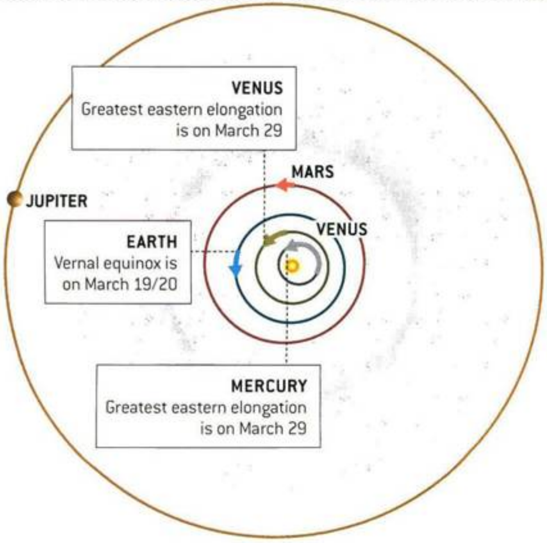
JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
March 15	March 15	March 15	March 15	March 15
–2.5	0.0	5.9	8.0	13.9
44.4"	18.9"	3.4"	2.2"	0.1"
100%	100%	100%	100%	100%
4.443	8.784	20.970	30.824	30.710
5.419	9.036	20.043	30.073	30.769
10h57.7m	6h27.3m	22h24.6m	21h07.1m	17h28.0m
8°11'	22°48'	–10°44'	–16°35'	–14°26'


JUPITER
MARS
VENUS

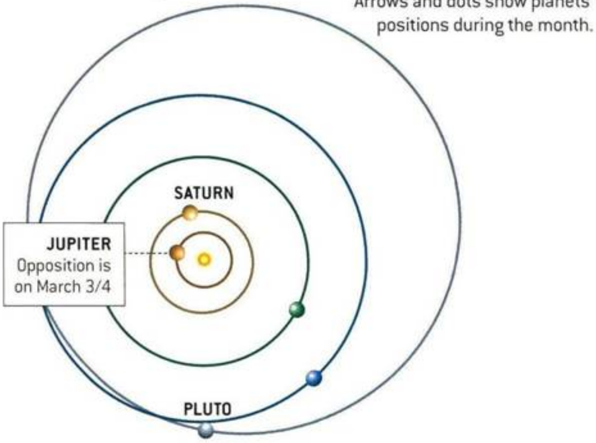
VENUS
Greatest eastern elongation is on March 29

EARTH
Vernal equinox is on March 19/20

MERCURY
Greatest eastern elongation is on March 29

The planets in their orbits

Arrows and dots show planets' positions during the month.


SATURN
PLUTO

JUPITER
Opposition is on March 3/4

NEW Celestron StarBright® XLT™ High Performance Optical Coatings Outperform The Competitor's UHTC.

StarBright XLT — An Optical System Breakthrough! Celestron has taken its renowned StarBright technology to *an even higher level of light transmission* with the introduction of our new **optional** StarBright XLT High Performance Optical Coating System.

StarBright XLT Optical System Design — You'll See The Light.

One of the most important factors in the evaluation of a Schmidt-Cassegrain telescope's optical system performance is its transmission — the percentage of incoming light that reaches the focal plane. The design of the XLT System accomplishes two crucial objectives: Develop a coating system that is optimized for visual use *and* for CCD/Photographic imaging.

Celestron StarBright XLT: The Bottom Line.

- **11% brighter than UHTC across the spectrum from 400nm to 750nm.** (See Fig.#1)
- **11% more photons will be detected with a CCD camera using StarBright XLT coating system compared to UHTC coatings** (See Fig.#2)
- **6% brighter than UHTC to the dark-adapted eye** (See Fig.#3)
- **16% brighter than our standard StarBright coating across the spectrum from 400nm to 750nm.**

System Transmission At Specific Wavelengths — Celestron StarBright XLT vs UHTC

	Wavelength (nm)	StarBright XLT	UHTC Measured	Percent Improvement
H-beta	486	87.5	83.0	**5%**
Helium II and O_3	496	88.0	84.0	**5%**
O_3	501	88.0	84.3	**5%**
Center of dark adapted vision	510	88.7	84.8	**5%**
Helium I	588	88.0	81.6	**8%**
N_2	655	84.0	73.8	**14%**
N_2 and H-alpha	658	84.0	73.0	**15%**
Sulfur II	673	83.0	72.0	**15%**

System Transmission for StarBright XLT and UHTC

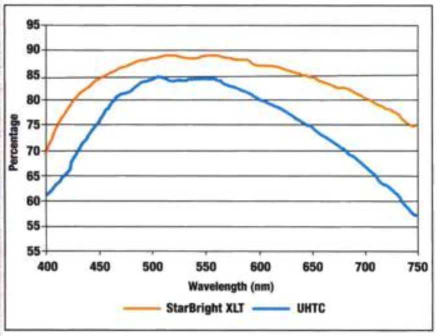


*Fig #1: This is a plot of measured system transmission for Celestron's StarBright XLT and UHTC coatings. The StarBright XLT coating has an overall average system transmission of 83.5% compared to UHTC at 75.1%. System transmission is determined by taking the measured value of the reflectance of the primary, times the reflectance of the secondary, times the transmission of the corrector lens.**

CCD Imaging — It's All In The Photons

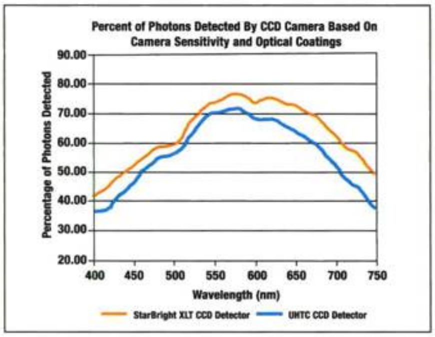


*Fig #2: StarBright XLT is not only optimized for visual use, it is also optimized for imaging. This plot takes into account the sensitivity of a popular CCD chip (KAK-3200 used in SBIG's ST10ME) in conjunction with the system transmission based on the optical coatings. Our measurements indicate that the CCD chip will detect 11% more photons with Celestron's StarBright XLT than UHTC.**

Coming Out of the Dark — StarBright XLT Performance Where It Counts

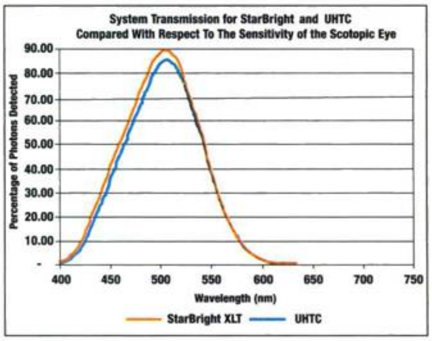


*Fig #3: The scotopic, dark adapted eye is most sensitive at about 510nm. The dark-adapted eye has nearly zero sensitivity below 400nm and above 650nm. This plot compares StarBright XLT and our measurement of UHTC taking into account the sensitivity of the human eye. The result is that StarBright XLT is a **6% improvement over UHTC** for visual observing .**

UHTC Coatings Don't Measure Up To StarBright XLT

In order to determine how our newly designed XLT performs compared to the competition, we tested several optical systems with UHTC coatings. All measurements have been conducted with spectrophotometers measuring light transmission of coated correctors and reflectance of coated mirrors. This allows us to compare the transmission of our correctors and the reflectance of our mirrors against those of the competition. To ensure the integrity, accuracy, and reliability of these test results, they have been independently verified. A detailed description of our testing process can be found on our website: **www.celestron.com/starbrightxlt.***

Percent differences are calculated by taking the comparison data percentage divided by the baseline data. Example: Measured average system transmission for UHTC is 75.1%. XLT average system transmission is 83.5%. 83.5% divided by 75.1% = 1.11 or 11% improvement. Measurement results are rounded to the nearest whole percentage.

The StarBright XLT System — What makes it different makes it better. — There are three major components that make up our StarBright XLT high transmission optical system design:

1. **Unique enhanced multi-layer mirror coatings** — Our mirror coatings are made from precise layers of aluminum (Al), SiO_2 (quartz), TiO_2 (titanium dioxide), and SiO_2. Reflectivity is fairly flat across the spectrum, optimizing it for both CCD imaging and visual use.
2. **Multi-layer anti-reflective coatings** — Made from precise layers of MgF_2 (magnesium fluoride), and HfO_2 (hafnium oxide). A rare element costing nearly $2000 per kilogram, hafnium gives us a wider band pass than titanium, used in UHTC coatings.
3. **High transmission water white glass** — Celestron Schmidt-Cassegrain optical systems with **optional** StarBright XLT coatings use water white glass instead of soda lime glass for the corrector lens. ***Water white glass transmits about 90.5% without anti-reflective coatings.*** That is 3.5% better transmission than uncoated soda lime glass. ***When water white glass is used in conjunction with StarBright XLT's anti-reflective coatings, the average transmission reaches 97.4% — an 8% improvement!***

For more information about StarBright XLT visit: www.celestron.com/starbrightxlt

StarBright XLT Pricing

All 8" Schmidt-Cassegrain Products	$125
All 9.25" Schmidt-Cassegrain Products	$175
All 11" Schmidt-Cassegrain Products	$225
All 14" Schmidt-Cassegrain Products	$275

NEW 2003 PRODUCT GUIDE

To request a copy of Celestron's new 2003 Product Guide, contact us at (310) 328-9560.

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CELESTRON ACCESSORIES

FOR MORE INFORMATION OR TO LOCATE AN AUTHORIZED CELESTRON DEALER, VISIT: WWW.CELESTRON.COM

OMNI® Eyepieces — 1 1/4"

- Focal lengths – 4mm, 6mm, 9mm,12.5mm, 15mm, 20mm, 25mm, 32mm, and 40mm
- **4-element premium symmetrical optical design**
- Fully multi-coated
- 52º (43º for 40mm) Field of View
- 2-step anodize process to prevent reflection from top surfaces
- Blackened lens edges

NEW!

4mm	$ 44.00
6mm	$ 44.00
9mm	$ 44.00
12.5mm	$ 44.00
15mm	$ 44.00
20mm	$ 44.00
25mm	$ 44.00
32mm	$ 54.00
40mm	$ 54.00

NEW!

OMNI® Barlow Lens — 1 1/4"

- 2x
- Fully multi-coated
- Short tube design

1-1/4"OMNI Barlow............$ 47.00

X-Cel® Eyepieces — 1 1/4"

- **6-element optical design utilizing ED glass**
- Focal lengths – 2.3mm, 5mm, 8mm,10mm, 12.5mm,18mm, 21mm, and 25mm
- Fully Multi-coated. All air-to-glass surfaces have 5 layer multi-coating
- Field of view 55°
- Parfocal – little to no focusing adjustments are needed when switching from a low power to high power eyepiece
- 20mm eye relief and soft rubber roll down eyecups
- More than 25mm of clear aperture even on the high powers for comfortable high power viewing
- Each eyepiece comes with a durable plastic case

NEW!

2.3mm	$ 69.00	12.5mm	$ 69.00
5mm	$ 69.00	18mm	$ 69.00
8mm	$ 69.00	21mm	$ 69.00
10mm	$ 69.00	25mm	$ 69.00

NEW!

E-Lux® Eyepieces 2"

- Focal lengths – 26mm, 32mm, and 40mm
- 3-element optical design
- **Fully multi-coated**
- Field of View — 56° (26mm and 32mm), 50° (40mm)
- 22mm Eye Relief

E-Lux® Eyepieces — 1 1/4"

- Focal lengths – 6mm, 10mm, 25mm, and 40mm
- Traditional Plössl optical design
- Fully-coated

2":		1-1/4":	
26mm	$ 69.00	6mm	$ 34.00
32mm	$ 69.00	10mm	$ 34.00
40mm	$ 79.00	25mm	$ 34.00
		40mm	$ 34.00

Axiom® Eyepieces — 1 1/4", 2"

- Focal lengths –

1-1/4": 15mm, 19mm, 23mm
2": 19mm, 34mm, 40mm, and 50mm

- **7-element optical design**
- **70° EXTRA WIDE** field of view (except 50mm)
- Fully multi-coated

1-1/4":	
15mm	$139.00
19mm	$149.00
23mm	$179.00
2":	
19mm	$189.00
34mm	$239.00
40mm	$289.00
50mm	$329.00

Ultima® Eyepieces — 1 1/4"

- **5-element hybrid optical design**
- Focal lengths – 5mm, 7.5mm, 12.5mm, 18mm, 30mm, 35mm, and 42mm
- Fully multi-coated
- Blackened lens edges

5mm	$ 79.00
7.5mm	$ 79.00
10mm	$ 79.00
12.5mm	$ 79.00
18mm	$ 79.00
30mm	$ 99.00
35mm	$109.00
42mm	$ 99.00

10mm Plössl Reticle Eyepiece — 1 1/4"

- Five-element guiding eyepiece
- Reticle pattern is a .0075" double spaced line system
- Multicoated optics for increased contrast
- Long eye relief
- High power is ideal for guiding
- 50° apparent field of view
- Optional illuminator is required

10mm Plössl Reticle Eyepiece —11/4"............$124.00

Ultima® 2x Barlow — 1 1/4"

- **Three-element apochromatic design**
- 27mm clear aperture
- Fully multi-coated

1-1/4"Ultima Barlow.......$ 79.00

Microguide Eyepiece — 1 1/4"

- Laser-etched reticle with a built-in, battery illuminator
- Multicoated 12.5mm Abbe (4-element) Orthoscopic
- Direct guiding on stars outside the center of the field of view
- Greatly improved off-axis guiding to capture much fainter, sharply focused guide stars without reducing limiting magnitude
- Measure position angles and separation of double stars

Microguide Eyepiece 1-1/4".......$194.00

Collimation Eyepiece

- For precise collimation of Newtonians and helpful for aligning Schmidt-Cassegrains
- Fits into 1-1/4" focusers or diagonals
- Alignment is easy using the small opening on one end and thin cross hairs at the other end
- More accurate than a simple collimation Tool

Collimation Eyepiece.......$ 39.00

Radial Guider

- Use with Schmidt-Cassegrain telescopes in prime focus, deep-sky imaging or astrophotography
- Simultaneously photograph and guide through the optical tube assembly of the telescope
- Adjustable prism and rotating eyepiece collar give wider section of sky for finding a guide star
- Eliminates the problem of differential flexure

Radial Guider.......$124.00

Reducer/Corrector

- Works with all Celestron C5, C8, C91/4 , C11 and C14 telescopes
- Minimizes coma and flattens field of view for pinpoint off-axis stars
- Reduces exposure times by 60% and increases field of view
- f/6.3 for C5, C8, C91/4 and C11 telescopes and f/7 for the C14 telescope

Reducer/Corrector.......$139.00

2" Mirror Diagonal

- 2' 90° Mirror Diagonal to thread on Schmidt-Cassegrain telescopes
- Includes an adapter to use with refractor telescopes
- Includes an adapter to accept 1 1/4" eyepieces
- Multicoated mirror
- Smooth mechanics that are precision manufactured for reliability

2" Mirror Diagonal.......$ 89.00

Stereo Binocular Viewer

- Allows you to adapt two eyepieces to the telescope for simultaneous viewing (like binoculars)
- A fantastic 3-D effect when observing many celestial objects

Stereo Binocular Viewer.......$649.00

Power Tank™

- 12-volt rechargeable power supply
- 7-amp hour
- Two 12V output cigarette lighter ports
- 3V, 6V and 9V outputs for accessories
- Built-in flashlight with red filter cap
- 800,000 candle power halogen emergency spotlight
- Booster terminal on rear side
- Built-in circuit breaker for safety
- Cigarette lighter adapter included
- AC adapter included (120V-220V)

NEW!

Power Tank............$ 69.00

Vibration Suppression Pads

- Reduces vibration time by almost 100% and decreases vibration amplitude
- The pads fit between the bottom of the tripod legs and the ground

Vibration Suppression Pads (Set of 3)............$ 59.00

Contrast-Booster Filter — 1 1/4"

by Baader

- Eliminates color aberration inherent in achromatic refractor telescopes
- Eliminates the blue hue around lunar and planetary subjects
- Multi-layer coatings for 95% transmission

NEW!

1-1/4" Contrast - Booster Filter............$ 49.00

Model A — for 1-1/4" eyepieces **Model B — for backthreads of SC's**

LPR (Light Pollution Reduction) Filters

- Made of high quality, flat polished optical glass
- Over 40 layers of coating
- Broadband anti-reflection coating prevents ghosting and improves contrast

LPR Filter — 1-1/4"....$ 69.00
LPR Filter Model B......$ 99.00

1 1/4" Polarizing Filter Set

- Transmits only light moving along a specific plane; increases contrast between surfaces with different planar transmissions
- Polarization effect makes blue skies a deeper blue, eliminates surface reflections and helps reduce atmospheric haze

1-1/4" Polarizing Filter Set......$ 39.00

Eyepiece Filter Sets — 1 1/4"

- An invaluable aid in planetary and lunar observing
- Reduces glare and light scattering
- Increase contrast, definition and resolution
- Lessens eye fatigue

#94119-10 (21, 80A, 15, Polarizing)	$ 44.00
#94119-20 (12, 25, 56, ND-25)	$ 44.00
#94119-30 (23A, 38A, 58, ND-50)	$ 44.00
#94119-40 (8, ND-13, 47, 82A)	$ 44.00

Night Vision Flashlight

- Two red LEDs
- Adjustable brightness
- Uses a single 9V battery (included).

Night Vision

Night Vision Flashlight.......$ 19.00

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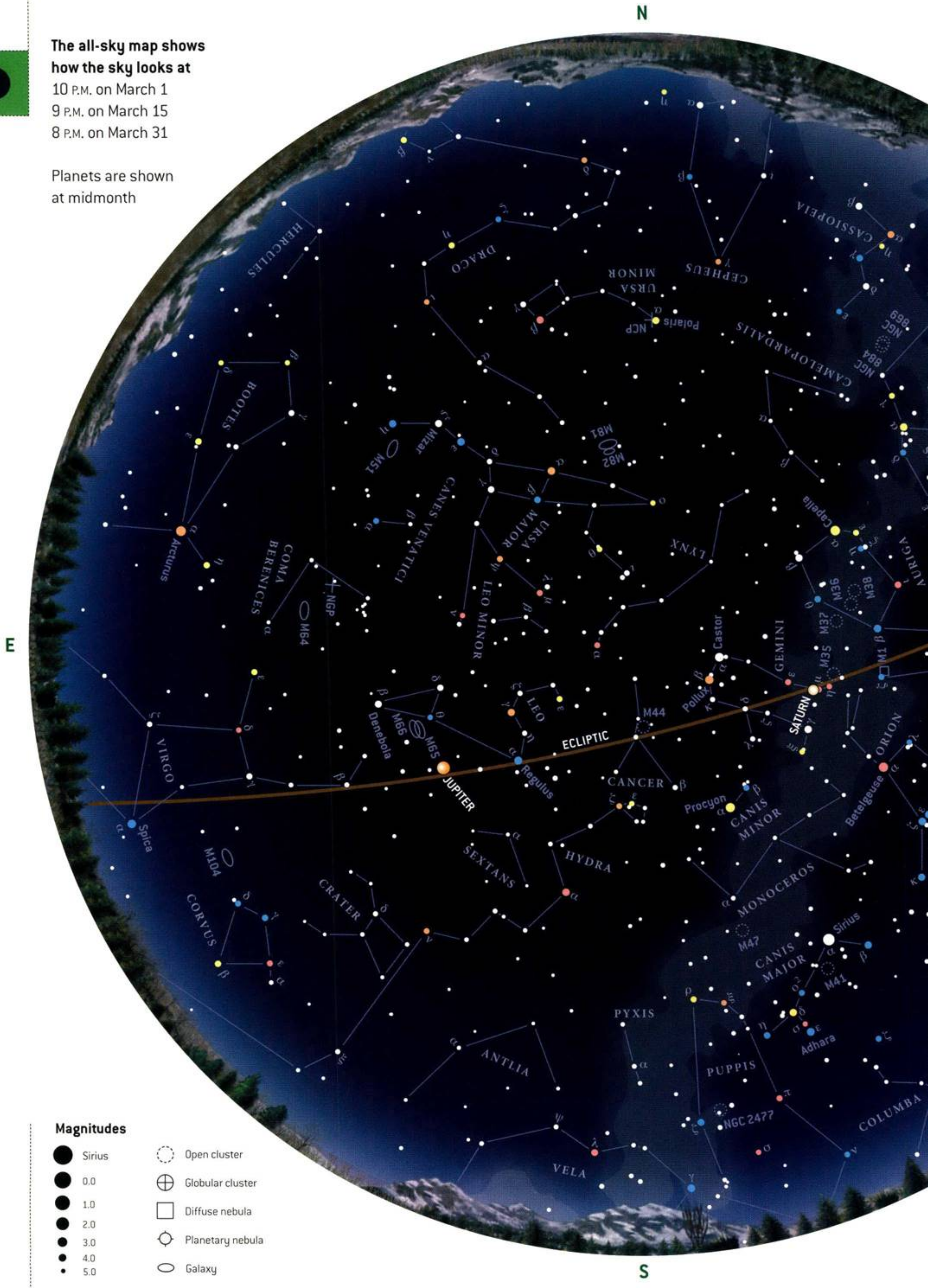
All prices shown in U.S. Dollars.

The all-sky map shows how the sky looks at
10 P.M. on March 1
9 P.M. on March 15
8 P.M. on March 31

Planets are shown at midmonth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M82
Mizar
M51
CANES VENATICI
URSA MAJOR
COMA BERENICES
NGP
M64
LEO MINOR
LYNX
Capella
AURIGA
M36
M38
M37
GEMINI
Castor
Pollux
M35
M1
SATURN
ORION
Betelgeuse
M44
LEO
Denebola
M66
M65
Regulus
ECLIPTIC
JUPITER
VIRGO
Spica
CANCER
Procyon
CANIS MINOR
M104
SEXTANS
HYDRA
CRATER
CORVUS
MONOCEROS
M47
Sirius
CANIS MAJOR
M41
Adhara
PYXIS
ANTLIA
PUPPIS
NGC 2477
COLUMBA
VELA
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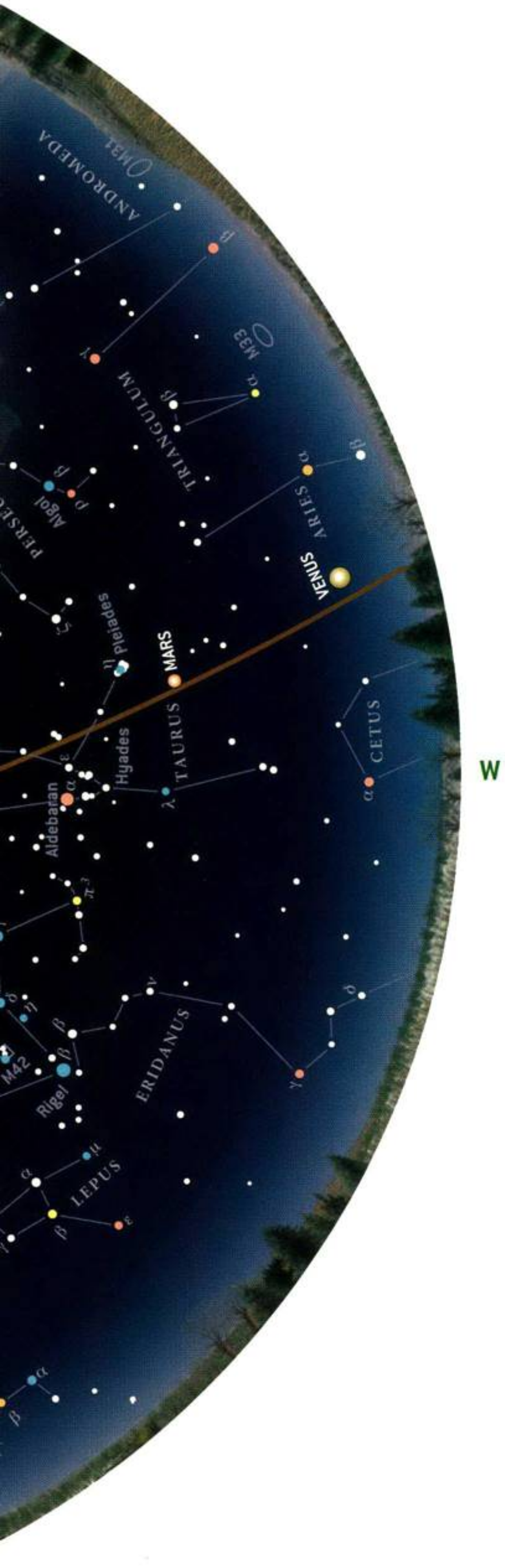
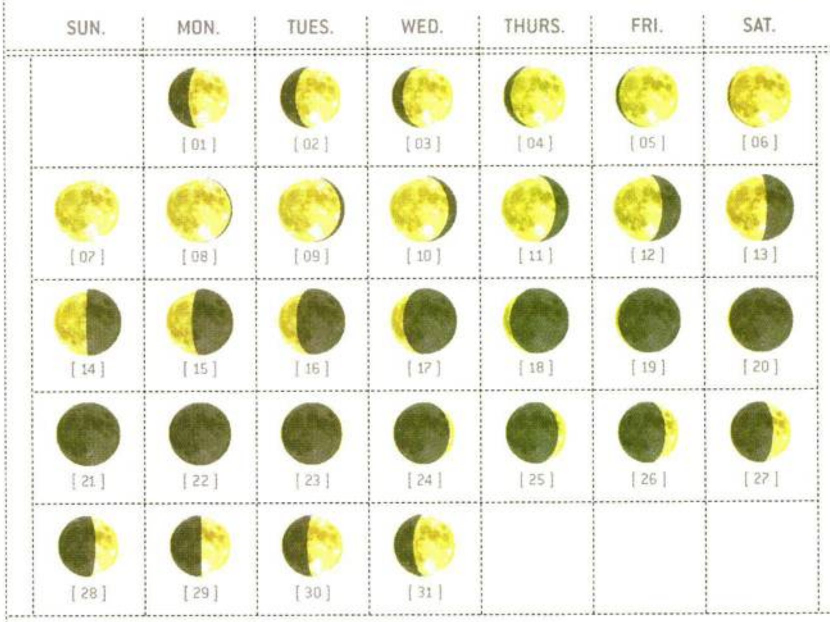
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

This map portrays the sky as seen near 35° north latitude at times shown in the upper left corner of the page. Located just outside the map are the four directions: no horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


ANDROMEDA
M31
M33
TRIANGULUM
PERSE
Algol
ARIES
VENUS
Pleiades
MARS
TAURUS
Hyades
Aldebaran
CETUS
ERIDANUS
M42
Rigel
LEPUS
W

march 04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01 The Moon passes 5° north of Saturn, 5 A.M. EST

03 Mercury is in superior conjunction, 9 P.M. EST

Jupiter is at opposition, midnight EST

06 The Moon passes 3° north of Jupiter, 11 A.M. EST

Full Moon is at 6:14 P.M. EST

07 Saturn is stationary, 10 A.M. EST

11 Asteroid Iris is at opposition, 9 A.M. EST

The Moon is at perigee (229,601 miles from Earth), 10:53 P.M. EST

13 Last Quarter Moon is at 4:01 P.M. EST

17 The Moon passes 5° south of Neptune, 4 A.M. EST

18 The Moon passes 4° south of Uranus, 3 P.M. EST

20 Vernal equinox is at 1:49 A.M. EST

New Moon is at 5:41 P.M. EST

21 The Moon passes 4° south of Mercury, midnight EST

24 The Moon passes 2° south of Venus, 4 P.M. EST

25 The Moon passes 0.8° north of Mars, 7 P.M. EST

27 The Moon is at apogee (251,358 miles from Earth), 2:01 A.M. EST

28 The Moon passes 5° north of Saturn, 2 P.M. EST

First Quarter Moon is at 6:48 P.M. EST

29 Mercury is at greatest eastern elongation (19°), 7 A.M. EST

Venus is at greatest eastern elongation (46°), noon EST

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The new Advanced Series and Advanced Series **Computerized GoTo** telescopes have been designed to offer the novice or more advanced user a selection of models with the **features, quality** and **value** that serious amateurs can appreciate. These scopes come on **NEW heavy-duty German Equatorial mounts** with **NEW ultra-sturdy 2" stainless steel legs** and center brace and accessory tray for superior stability, rigidity and vibration dampening. The Advanced Series comes in a choice of refractor, reflector and Schmidt- Cassegrain models. The refractor models range from a 4" to an impressive 6" aperture. For even more light gathering power there are 6", 8" and a **NEW 10" Newtonian** reflector**.** There are also 5", 8" and 9 1/4" Schmidt-Cassegrain optical designs that feature Celestron's **precision matched and hand-figured optical systems.**

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Our **new CG-5 German Equatorial Mount** has precision worm gears on both axes for extremely smooth tracking and slewing. The CG-5 uses large shaft and bearings and substantial base castings for additional stability. The key element that makes this system the most stable in its class is the **NEW heavy-duty tripod** with **larger and more substantial legs** that provide excellent damping characteristics for more stable views. The CG-5 also has a convenient **latitude scale** for easier alignment and an **optional polar finder scope** for the ultimate in precision alignments.

Additional Specifications — Computerized Models

Hand Control	Double line, 16 character Crystal Display; 19 fiber optic backlit LED buttons
Motor: Type	DC Servo motors with encoders, both axes
Max Slew Speed	4°/second
Software Precision	24bit, 0.08 arcsec calculation
Hand Control Ports	RS-232 communication port on hand control
Motor Ports	Aux Port, Autoguide Ports
Tracking Rates	Sidereal, Solar and Luner
Tracking Modes	EQ North & EQ South
Alignment Procedures	AutoAlign, 2-Star Alignment, Quick Align
Database	40,000+ objects, 400 user defined programmable objects

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(#11046)

We are proud to offer the GT versions of the Advanced Series on a computerized **GoTo** version of Celestron's sturdy CG-5 mount. Couple this solid mount with the included **NexStar® computer control system** and utilize many of the same features as Celestron's most advanced GoTo telescopes like an **Autoguider port** for long exposure deep sky astrophotography. **GoTo models are also upgradeable to GPS** with the optional **CN16 GPS Accessory (#93963).** It allows your telescope to pinpoint your position on the Earth, the date and time, and makes the alignment process faster and easier than ever before!

C10-NGT
(#11048)

These GoTo versions of the Advanced Series also come loaded with new software features and **over 40,000 database objects**. Capable of holding over 35 lbs of payload and slewing at 4° per second, you will be able to instantly point to any of the celestial objects in the database.

NEW 2003 PRODUCT GUIDE

To request a copy of our new 2003 Product Guide, contact us at (310) 328-9560.

Specifications — All Advanced Series Telescopes

	21016 C4-R	11071/11072 C5-S	31056 C6-N	21019/21020 C6-R	11025/11024 C8-S	31061/31062 C8-N	11045/11046 C9 1/4-S	11047/11048 C10-N
Optical Design	102mm (4.0") refractor	127mm(5") Schmidt-Cassegrain	150mm (6.0") reflector	150mm (6.0") refractor	203mm (8") Schmidt-Cassegrain	200mm (8.0") reflector	235mm (9.25") Schmidt-Cassegrain	254mm (10") reflector
Focal Length	1000mm f/10	1250mm f/10	750mm f/5	1200mm f/8	2032mm f/10	1000mm f/5	2350mm f/10	1200mm f/4.7
Finderscope	6x30	6x30	6x30	9x50	6x30	9x50	6x30	9x50
Mount	CG-4 Equatorial	CG-5 Equatorial	CG-4 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial
Eyepiece	1-1/4" – 20mm (50x)	1-1/4" – 25mm (50x)	1-1/4" – 20mm (38x)	1-1/4" – 20mm (60x)	1-1/4" – 25mm (81x)	1-1/4" – 20mm (50x)	1-1/4" – 25mm (94x)	1-1/4" – 20mm (60x)
Star Diagonal	1-1/4"	1-1/4"	n/a	1-1/4"	1-1/4"	n/a	1-1/4"	n/a
Accessory tray	yes	yes	yes	yes	yes	yes	yes	yes
Tripod	Aluminum	2" Stainless Steel	Aluminum	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel
CD ROM	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky L1

PRICING*: C10-NGT (#11048): $1,149 + $95 S&H; C10-N (#11047):$849 + $75 S&H; C9¼-SGT (#11046): $1,699 + $105 S&H; C9¼-S (#11045): $1,399 + $85 S&H; C8-SGT (#11026): $1,299 + $75 S&H; C8-S (#11025): $999 + $85 S&H; C8-NGT (#31062): $949 + $85 S&H; C8-N (#31061): $649 + $65 S&H; C6-RGT (#21020): $999 + $95 S&H; C6-R (#21019): $799 + $75 S&H; C6-N (#31056) $399 +$50 S&H; C5-SGT (#11072): $1,099 + $75 S&H; C5-S (#11071): $849 + $65 S&H; C4-R (#21016): $399 + $40 S&H

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THE DEEP SKY

The region surrounding Orion's Belt is studded with a broad array of celestial wonders.

Commanding the southern sky as darkness falls, the mighty hunter Orion grabs attention away from sparkling Sirius to the lower left. The massive clouds of interstellar dust and gas in this region of the Milky Way have given birth to a marvelous variety of astronomical species.

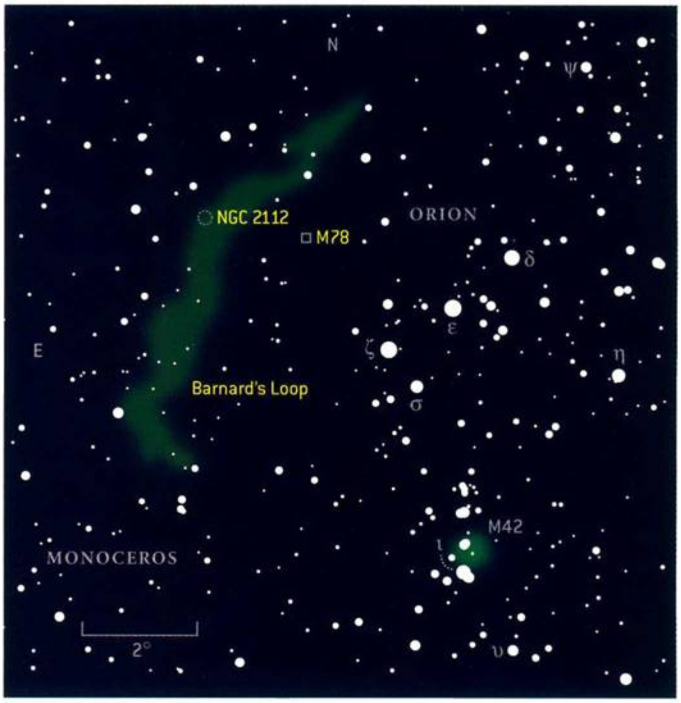
The Orion Nebula (M42) ranks among the finest telescopic objects in the sky. The bright swirls of gas that surround the Trapezium star cluster invite wonder and awe — and easily can chew up much of an evening's observing if you choose. Mesmerizing as it may be, take at least a few minutes to see what else this region holds.

While you let your scope cool down in the late-winter air, point your binoculars at Orion's Belt. Snaking in a large S shape between the middle and right belt stars (Epsilon [ε] and Delta [δ] Orionis), open cluster Collinder 70 boasts more than a dozen sparkles. At a distance of 1,400 light-years, the cluster forms the northern end of the much larger Orion OB association. O and B stars rank as the hottest and most massive main sequence stars. Thousands of fainter stars more like the Sun also reside here, but backyard observers can't see them. The belt stars do not belong to this group — they lie either in the foreground or do not share the same motion through space.

To the north and east of the belt stars lies a small group of gas clouds. The brightest of these is Messier 78, which actually was discovered by Messier's assistant, Pierre Méchain, in 1780. He described it as "two fairly bright nuclei [stars] surrounded by a nebulosity." The cloud appears to have a fairly sharp boundary near those two stars that contrasts with the other edge, where it fades gradually. Using a 10-inch or larger scope under a dark sky, you may find the other gas clouds in the same field of view.

Next, nudge your telescope due north by less than a Moon-width and wait six minutes for Earth's rotation to bring open cluster NGC 2112 into sight. Compared with the dazzle of Orion's Belt, this grouping appears rather sparse, so you'll have to be away from city lights to see it. It spans about one-third the apparent size of the Moon.

NGC 2112 appears embedded in the elusive Barnard's Loop. Easily picked up on film during moderately short exposures, Barnard's Loop appears directly to the eye only with a piece of modern technology. You'll need to use an H-beta filter under a very dark sky, both of which you're likely to find at a star party. Shield your eye as much as possible to avoid glare, then patiently scan back and forth to pick up the feeble, ghostly gray glow. Vigorous interstellar winds blown by the hot young stars in the Orion nursery have created a huge gas bubble; Barnard's Loop marks the eastern edge of that bubble.



REFLECTION NEBULA M78 may be less glamorous than its Orion Nebula cousin, but it's fascinating in its own right and well worth a look while exploring Orion the Hunter. JASON WARE

Martin Ratcliffe *is former president of the International Planetarium Society.* **Alister Ling** *is a meteorologist for Environment Canada.*

THE PLANETS

The five planets known in antiquity all put on outstanding appearances in March, delivering great views to observers using telescopes, binoculars, and even their naked eyes.

Soon after sunset, **Venus** makes its presence known. Shining brilliantly at magnitude –4.3, the steady beacon appears unmistakable, high in the west. No other planet or star shines brighter in the night sky. Once the sky grows dark, the familiar constellations of Pisces the Fish and Aries the Ram provide a faint, starry background for Venus. Look for a slim crescent Moon 2° to the left of Venus on March 24.

The view of Venus through a telescope shows a distinct phase. In early March, the planet appears gibbous, rather like our own Moon on the 1st. On this date, the Sun illuminates 65 percent of Venus's visible disk. Notice that the lit portion faces the Sun, which has just dipped below the western horizon. (Remember that a telescope often inverts the view, however.)

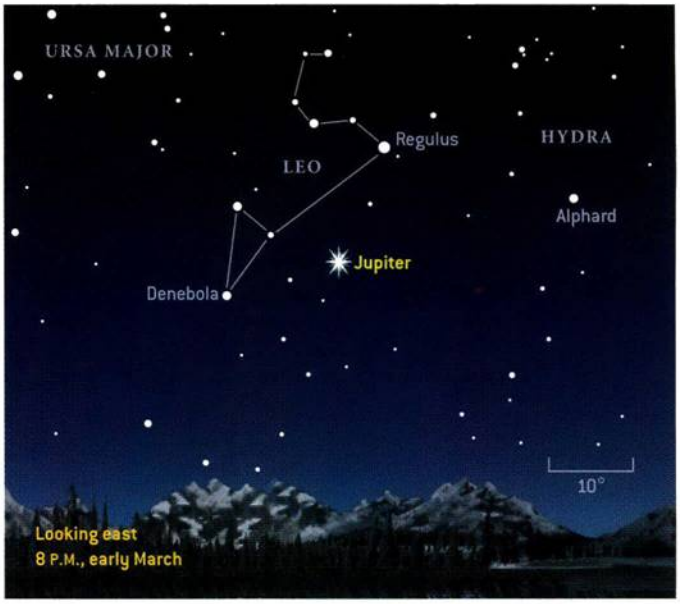
By March 31, Venus displays a 50-percent-lit disk from its perch just 2° below the Pleiades star cluster (M45). When do you think Venus appears exactly half-lit? Look for the moment when the terminator makes a perfectly straight line. Venus reaches its greatest elongation east of the Sun on March 29.

The shrinking phase of Venus correlates with an increase in the planet's apparent diameter. The disk grows from 18" to 24" during March — a result of Venus moving closer to Earth. The distance between our two worlds shrinks from 86 million miles to 65 million miles this month.

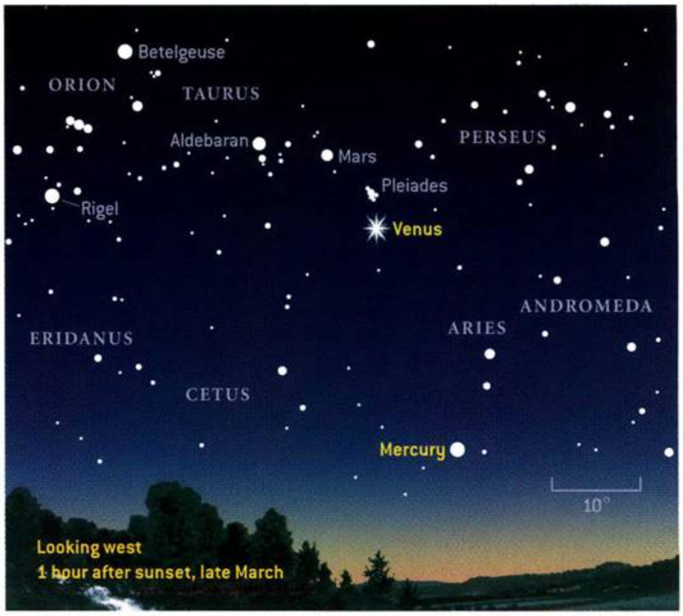
Coincidentally, **Mercury** reaches its greatest eastern elongation on the same date as Venus. Whereas Venus stands 46° from the Sun, Mercury attains only 19° because it has a smaller orbit around our star. By March 17, Mercury appears 6° above the western horizon thirty minutes after the Sun goes down and shines at magnitude –1.2. On the 22nd, a slender crescent Moon stands 7° to the upper left of Mercury. The planet fades to magnitude 0.0 by March 29, when you'll find it 12° above the horizon thirty minutes after sunset.

Throughout March, Venus plays catch-up to **Mars**. On the 1st, 22° separate the pair, a value that drops to 9° by the 31st. (Mars beats Venus to the Pleiades, passing 3° south of the cluster on the 19th.) The shrinking gap is only a line-of-sight effect, however — Mars lies far beyond Venus. Mars shines at magnitude 1.3 and nearly matches Aldebaran, the brightest star in Taurus, in both brightness and color. The planet's tiny disk spans just 5" this month, revealing little through a telescope.

On the first day of March, **Saturn** stands 9° to the right of the gibbous Moon. Shining at magnitude –0.1 among the stars of Gemini, the planet becomes visible high in the east-northeast as twilight deepens. The planet's westerly motion toward Mu (μ) and Eta (η) Geminorum, the stars at the constellation's northwestern corner, comes to a halt on March 7. Saturn then resumes its normal easterly trek against the background stars.



Looking east
8 P.M., early March



Looking west
1 hour after sunset, late March

Saturn remains visible until well after midnight in early March. The planet's disk then spans 19", and its wide-open ring system more than *doubles* this measurement. Now that three months have passed since one of the best oppositions in recent times, the shadow of the planet on the rings should be quite noticeable.

Jupiter reaches opposition on March 3/4, when it lies opposite the Sun in our sky and remains visible all night. During the evening hours, it climbs higher in the east while Venus sinks in the west. The Full Moon stands 6° east of Jupiter on the 6th.

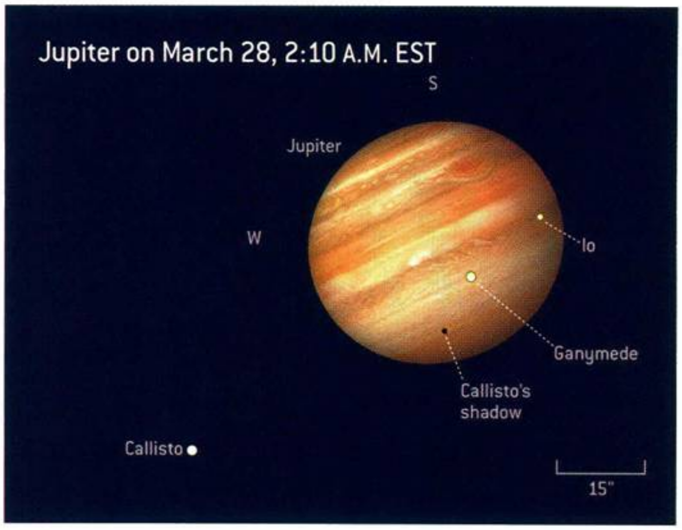
Jupiter shines at magnitude –2.5, making it the second brightest planet in the sky and conspicuous within half an hour after sunset. Leo the Lion, king of the beasts, creates an elegant backdrop for the king of the planets. The globe of Jupiter spans 44", the same breadth as Saturn's rings. Features in the jovian cloudtops are much easier to see than those on Saturn; however, some of the most fascinating features are subtle. You'll see more if you practice patience at the eyepiece, waiting for those rare moments of still air.

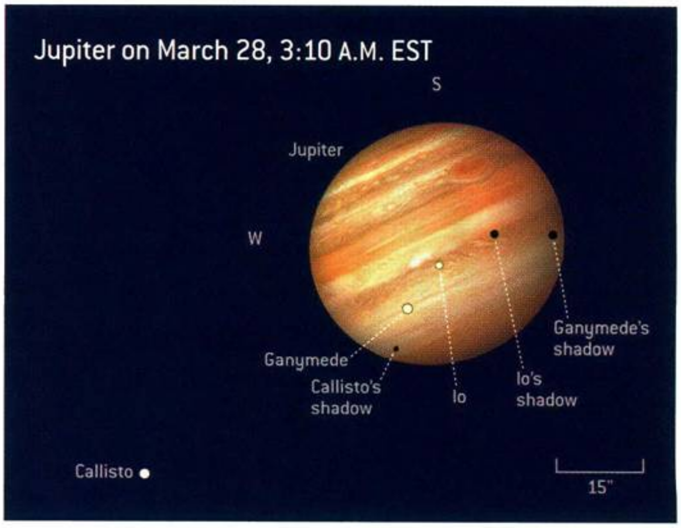
While the turbulence in Jupiter's atmosphere calls for attention, the moons perform their own waltz around the planet. Once every orbit, each Galilean satellite passes in front of and behind Jupiter. When either happens, Jupiter seems to lack that moon. The moons also cast shadows on Jupiter's disk when they pass in front of the planet. On a number of occasions this month, the shadows of two moons fall on Jupiter at the same time — rare events worth viewing.

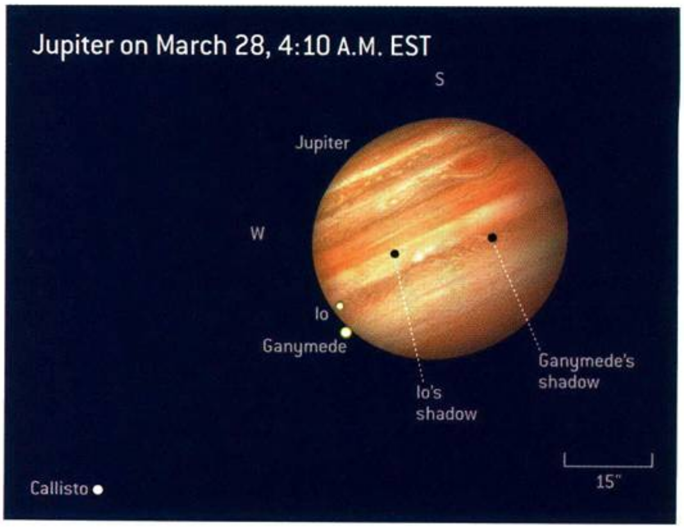
An even rarer event occurs on March 27/28, when three satellites simultaneously cast their shadows on Jupiter. To top things off, the fourth satellite passes behind the planet that same night.

Let's look at the details of this rare triple shadow transit. (All times are given in Eastern Standard Time; subtract one hour to convert to CST, two hours for MST, and three hours for PST.) Callisto begins to transit Jupiter's disk at 6:52 p.m. and reappears at 9:59 p.m. Later, it will be the only moon visible. Callisto's shadow transits Jupiter between 11:59 p.m. and 3:19 a.m. Ganymede begins a transit at 12:44 a.m., leaving three satellites visible. However, Europa stands poised to slink behind Jupiter, disappearing at 1:32 a.m., leaving two moons visible. Io transits Jupiter starting at 1:59 a.m., followed by its shadow at 2:32 a.m., leaving only one moon separate from the planet's disk.

As Callisto's shadow is about to leave Jupiter's disk, Ganymede's shadow begins a transit at 3:00 a.m. For the next nineteen minutes, three satellite shadows appear on Jupiter's disk while Europa lies hidden behind the planet. Callisto's shadow leaves Jupiter at 3:19 a.m. However, between 1:59 a.m. and 4:05 a.m., Jupiter appears to have only one moon. Ganymede reappears from transit at 4:05 a.m., and nine minutes later, Io ends its transit, bringing three moons into view. Io's shadow leaves Jupiter at 4:48 a.m. Europa reappears from behind Jupiter at 5:27 a.m., followed, finally, by Ganymede's shadow, which leaves the planet's disk at 6:23 a.m., ending a unique night of jovian satellite drama.


Jupiter on March 28, 2:10 A.M. EST


Jupiter on March 28, 3:10 A.M. EST


Jupiter on March 28, 4:10 A.M. EST

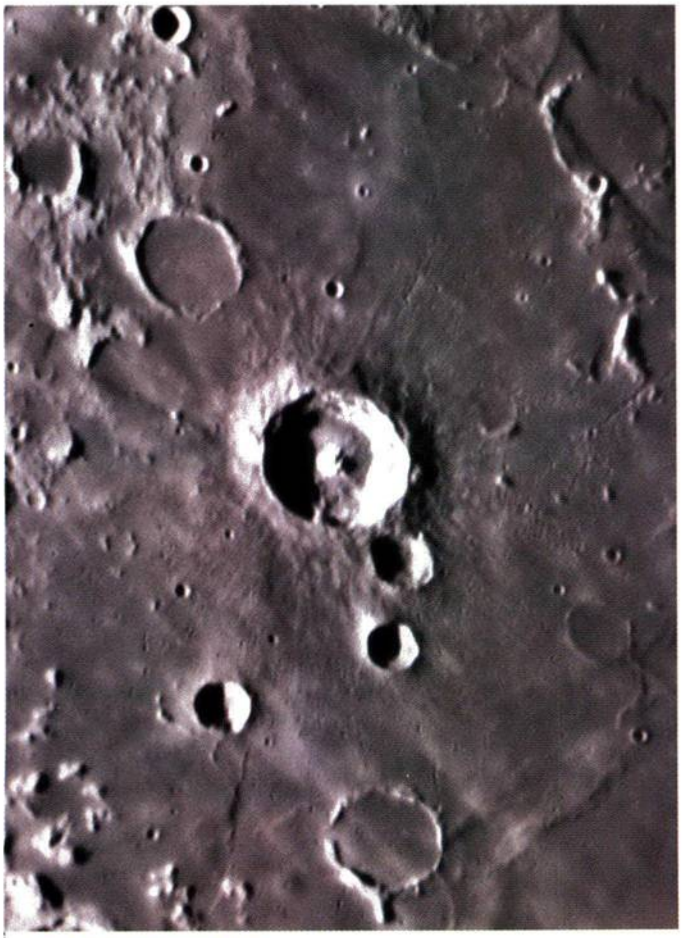
METEORS AND MOONS

The crater Bullialdus has everything a dedicated lunar observer could want. The more distant moons orbiting Jupiter partake in several events, highlighted by a rare triple shadow transit.

No significant meteor showers occur during March. The nightly rate of sporadic meteors seen from any one location averages around seven per hour. If a meteor flares brighter than Venus, it's called a fireball. These appear occasionally, adding a special exclamation to a night of observing.

Bully for Bullialdus

Few lunar craters show as complete an array of features as Bullialdus. There's a fine central peak, a partially flooded floor, and terraced walls; even the area surrounding the crater shows intricate detail. You can find Bullialdus in Mare Nubium, which lies in the southwestern quadrant of the Moon not far west of the Straight Wall. The crater measures 38 miles across. Under the low-lighting conditions present soon after sunrise or just before sunset at the crater, the outer walls of Bullialdus reveal a complex array of ridges and chains of secondary craters.



THE CRATER BULLIALDUS [center] features a high central peak with a partially flooded floor and terraced walls. FROM *THE CONSOLIDATED LUNAR ATLAS* [LPL/UA]

The central mountain peak appears very bright. Its appearance takes on different forms as the lighting changes from day to day. Look for the ridge that appears to run from the peak to the southern terraced wall. Under the best conditions, you can make out some of the tiny craterlets that dot the crater's flooded floor. The crater's distinct rim looks polygonal, and the 16-mile-wide companion crater, Bullialdus A, crowds the crater's southern flank. Bullialdus B lies about 10 miles west-southwest of A and sports two short, bright streaks evident on the surrounding mare.

In contrast to these distinct craters is Lubiniezky, a lava-flooded crater about 30 miles north-northwest of Bullialdus's rim whose walls have been almost completely submerged. Lubiniezky clearly formed before both the impacts that created Bullialdus and its immediate neighbors and the flooding of the Nubium basin.

Jupiter's satellites

Rare occultations, eclipses, and transits involving the outer Galilean moon, Callisto, continue. During each 12-year orbit of Jupiter around the Sun, only two such series take place. The current one began in late 2001 and continues until September 2004. During this time, sixty-six eclipses occur. The events listed in the table above are given in 24-hour format in both Universal Time and Eastern Standard Time. Events that occur on either side of midnight are shown twice because the date changes for observers in Europe or North America. Tr = transit; I = ingress; E = egress; Oc = occultation; Sh = shadow transit; Ec = eclipse; D = disappearance; R= reappearance. The events are worth viewing due to their relative rarity. Not all events are visible from the United States. Note the March 28 shadow transit takes place at the same time as shadow transits by Io and Ganymede (see page 65).

/// MARCH CALLISTO EVENTS

	{ UT }	*{ EST }*	*{ Event }*
2nd		20:33	IV.Ec.D.*
3rd	1h33m		IV.Ec.D.*
	5h08m	0:08	IV.Ec.R.
11th	9h35m	4:35	IV.Tr.I.
	10h58m	5:58	IV.Sh.I.
	12h29m	7:29	IV.Tr.E.
	14h26m	9:26	IV.Sh.E.
19th	16h13m	11:13	IV.Oc.D.
	19h15m	14:15	IV.Oc.R.
	19h36m	14:36	IV.Ec.D.
	23h03m	18:03	IV.Ec.R.
27th	23h52m	18:52	IV.Tr.I.
		21:59	IV.Tr.E.*
		23:59	IV.Sh.I.*
28th	2h59m		IV.Tr.E.*
	4h59m		IV.Sh.I.*
	8h19m	3:19	IV.Sh.E.

*Events that occur on either side of midnight are shown twice.

COMETS AND ASTEROIDS

Comet C/2002 T7 (LINEAR) drops into evening twilight before returning even brighter on mid-April mornings. Meanwhile, asteroid Ceres picks up its eastward pace in Gemini.

Gliding past Pegasus

The show has only begun, as Comet C/2002 T7 (LINEAR) puts on a classic comet tease act. We've been watching it brighten gradually into binocular range all winter, and now it's going to disappear before it hits its peak. No need to worry, however — the comet is taking just a brief intermission behind the Sun before it reappears before dawn in mid-April as a 3rd-magnitude sight to behold.

In early March, point your binoculars due west about an hour after sunset and scan upward about 20°. If you stretch out your arm, spread your fingers, and place your thumb on the horizon, then your pinky should hit the right spot. The only bright star in this area is Gamma (γ) Pegasi, which lies about one binocular field of view above the comet.

You should see a small but elongated, fuzzy blob. You'll probably need a telescope (any will do) to pick out the tail extending from the bright core. Remember that many scopes invert the image, so the tail may appear to point down. In reality, comet tails always point away from the Sun.

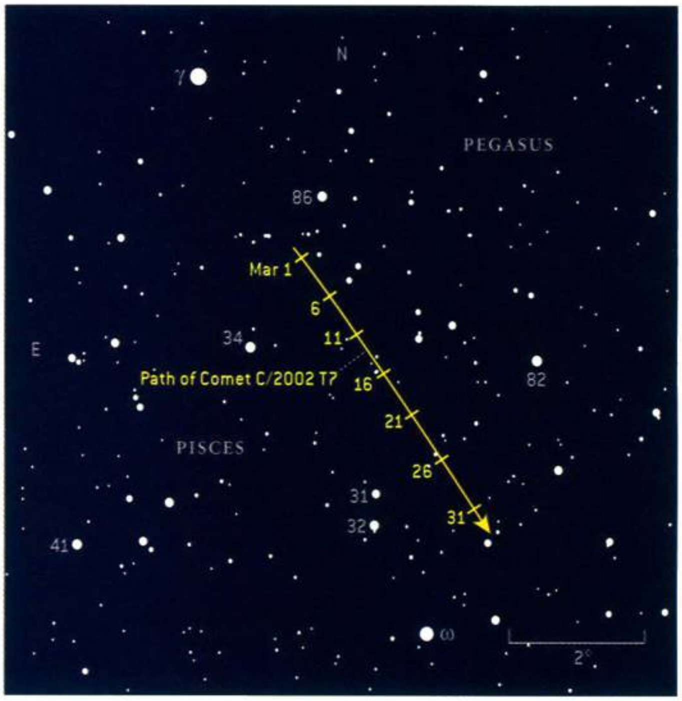
This dirty snowball appears to be a stray. All periodic comets have elliptical orbits, while most others have parabolic orbits. The latter come from the Oort Cloud at the solar system's edge and will return there, never to be seen again. Yet C/2002 T7 has an even higher-energy hyperbolic orbit, which suggests an interesting origin. It could be a stray from another solar system, but it more likely suffered a close encounter in the Oort Cloud that swung it sunward.

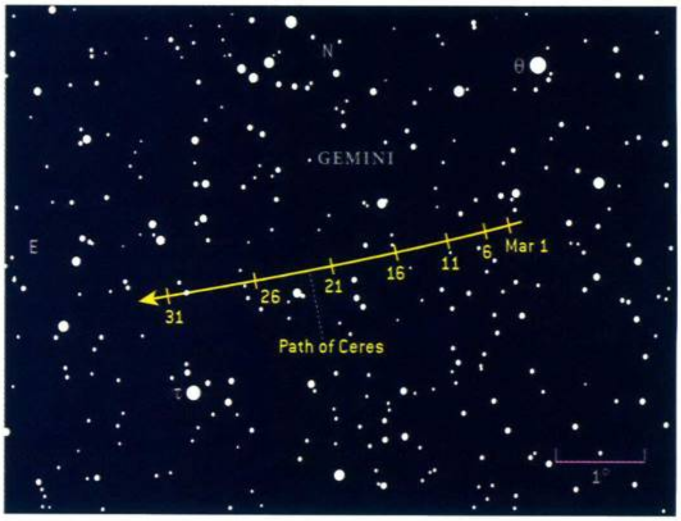
Ceres plies the Twins

Asteroids, just like planets, perform a loop in the sky called retrograde motion. Most of the time these objects travel eastward against the background stars, but as Earth overtakes them on its smaller, faster orbit, they appear to backtrack, only to resume their normal course after a couple of months.

When March begins, the first asteroid ever discovered, 1 Ceres, will have finished its hairpin loop in Gemini. (It will split the Castor–Pollux pair by the end of April.) At 8th magnitude, it's a bit faint for most binoculars, but it will not present any challenge for a backyard scope. Avoid the first few evenings of the month because glare from the nearby Moon will wash out the sky.

Use the slightly brighter 7th-magnitude stars that lie nearby to guide you to Ceres. If its position does not give it away, make a quick sketch of the field and come back a night or two later to see which "star" has moved. A scope with excellent optics pushed past 500x will show Ceres as a tiny dot, barely bigger than the Airy disk of a star. The Airy disk is not a star's true disk, but an artifact of light's wave nature.





NEAT southern comet

Comet C/2001 Q4 (NEAT) should make headlines when it vaults into the northern sky in May. Lucky observers in the Southern Hemisphere don't have to wait, however; C/2001 Q4 should be perfectly placed as it tracks slightly north of the Small Magellanic Cloud this month and glows nicely at 5th magnitude. ■

LUMICON

LUMICON FILTERS "World's Best"

Lumicon International offers you the best and most extensive line of astronomical filters in the world. Filters for every imagined visual and astrophotographic application, in many configurations and sizes. Filters for deep-sky objects, galaxies, nebulae, planets, planetary nebulae, light-polluted skies, comets, and solar prominences. All UHC, Deep Sky, Oxygen III, and H-Beta filters are individually inspected and tested on a Perkin-Elmer Double-Beam Spectrophotometer. We proudly inscribe the % transmission for each of the primary lines. All made in the USA, and assembled in our new factory in California. All Lumicon International products come with a 100% satisfaction guarantee. Please visit our website at: www.lumicon.com for further information.

LUMICON DEEP SKY FILTER

The Lumicon Deep-Sky Filter is THE foremost broadband filter, blocking ALL mercury-vapor as well as high & low pressure sodium-vapor lamp light, neon lights and airglow, while transmitting the rest of the visible spectrum. The superior contrast gain between the object you're viewing and the black background of space allows you to enjoy viewing galaxies, nebulae, star clusters, comets, etc. from light-polluted urban skies, making it the best all-around visual light pollution filter. Ideal for visual or photographic use.

.965" – $89.95 • 1.25" – $99.95 • Brandon 1.25" – $99.95 • 2" T-Threaded – $199.95 • 48mm – $199.95 • 72mm – $399.95 • Visual Back – $199.95 • 39mm Nikon – $299.95 • 43mm Nikon – $299.95

LUMICON UHC FILTER

The original Lumicon Ultra-High-Contrast narrow bandpass filter (24nm) isolates the two doubly-ionized oxygen lines (496 and 501nm lines) and the H-beta line (486nm) emitted by planetary and most emission nebulae. The result is superb views of the Orion, Lagoon, Swan and other extended nebulae. This makes the Lumicon UHC the best all-around dark-sky nebular filter available.

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back SCT – $199.95

LUMICON OXYGEN III FILTER

The renowned, original Lumicon OIII narrow bandpass filter (11nm) isolates just the two doubly-ionized oxygen lines (496 and 501nm lines) emitted by planetary and extremely faint nebulae. Produces near-photographic views of the Veil, Ring, Dumbbell and Orion nebula, among many other objects. You will be amazed at what the OIII filter allows you to see!

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back SCT – $199.95

LUMICON HYDROGEN-BETA FILTER

The Lumicon H-Beta Filter isolates only the Hydrogen-Beta line of the spectrum (486nm). Now you can view extremely faint, special objects such as the Horsehead, Cocoon and California Nebulae. In many cases, the Lumicon H-Beta Filter is the ONLY way to view these objects. A steady, transparent sky, with an 8" or larger instrument, combined with the Lumicon H-Beta Filter, all make an unbeatable combination for viewing those "notch in the belt" objects.

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back – $199.95

LUMICON NIGHT-SKY H-ALPHA FILTER, FOR BLACK AND WHITE DEEP-SKY PHOTOGRAPHY

The Lumicon Night-Sky H-Alpha Filter is a powerful photographic aid in overcoming light pollution during deep-sky photography, and will help you achieve strikingly improved results in telephoto lens B&W astrophotography. It is ideally matched to hypersensitized 2415 film, and will reduce light pollution 10-fold, making it ideal for photography of faint emission nebulae.

Transmission for this sharp-cut-off filter is zero below 630nm, 90% at Hydrogen-Alpha 656nm, and 90-98% from 656nm to the near infrared. Both filter surfaces have high-efficiency anti-reflection coatings for maximum performance.

Exposures may be increased 2-10 times with the Night-Sky H-Alpha Filter, depending on the faintness of the nebula.

48mm–$69.95 • 58mm–$79.95 • 77mm–$89.95 • 82mm–$99.95

PHOTO-VISUAL FILTER

NEW

For Lunar and Planetary user.

#8-Light Yellow Filter, 1.25"; #11-Yellow-Green Filter, 1.25"; #12-Yellow Filter, 1.25"; #15-Dark Yellow Filter, 1.25"; #21-Orange Filter, 1.25"; #23A-Light Red Filter, 1.25"; #25-Red Filter, 1.25"; #29-Dark Red Filter, 1.25"; #38A-Dark Blue Filter, 1.25"; #47-Violet Filter, 1.25"; #56-Green Filter, 1.25"; #58-Dark Green Filter, 1.25"; #80A-Medium Blue Filter, 1.25"; #82A-Light Blue Filter, 1.25"; ND13-Neutral Density Filter, 1.25"; ND50-Neutral Density Filter, 1.25" – $19.95/each • ***Buy any 4 get 1 Free - Limited Time Offer.***
• Single Polarizer Filter, 1.25" – $29.95 • Rotating Polarizer Filters, 1.25" – $39.95

#8-Light Yellow Filter, 2"; #11-Yellow-Green Filter, 2"; #12-Yellow Filter, 2"; #15-Dark Yellow Filter, 2"; #21-Orange Filter, 2"; #23A-Light Red Filter, 2"; #25-Red Filter, 2"; #29-Dark Red Filter, 2"; #38A-Dark Blue Filter, 2"; #47-Violet Filter, 2"; #56-Green Filter, 2"; #58-Dark Filter, 2"; #80A-Medium Blue Filter, 2"; #82A-Light Blue Filter, 2"; ND13-Neutral Density Filter, 2"; ND25-Neutral Density Filter, 2"; ND50-Neutral Density Filter, 2" • Ultra Violet (Clear) Filter, 2" – $29.95/each • ***Buy any 4 get 1 Free - Limited Time Offer.***
• Single Polarizer Filter, 2" – $39.95 • Rotating Polarizer Filters, 2" – $49.95

LUMICON MINUS VIOLET FILTER FOR COLOR OR BLACK AND WHITE PHOTOGRAPHY

The Lumicon Minus Violet Filter greatly improves photographs taken through lens systems, producing pinpoint star images. It is especially recommended for all telephoto lenses. This filter is made from optically flat, specially-made colored glass, and has anti-reflection coatings on both surfaces.

Recommended Films

All films can be used with the Minus Violet Filter; hypersensitized 2415 is the recommended B&W film, and is available directly from Lumicon or from any of Lumicon's authorized dealers.

Visual Use

The Minus Violet Filter can eliminate or greatly reduce the blue halo sometimes seen around stars through refracting telescopes. It is ideal for observing the moon and planets.

48mm – $49.95 • 58mm – $59.95 • 72mm – $69.95

LUMICON INFRARED BLOCKING FILTER

The Lumicon Infrared Blocking Filter completely blocks all infrared light above 750nm. Its versatile, anodized aluminum cell has 42mm male T-threads on one side and 48mm male threads with 42mm female T-threads, internal, on the other. Great for CCD camera infrared blocking purposes.

2" – $99.95

Infrared Blocking Filter 1.25" coming soon.

LUMICON UV DUST SEAL FOR MOST SCTs

The Lumicon UV Dust Seal keeps dust and insects out of your telescope. The seal mounts on the back of your SCT and accepts all attachments. It is an ultraviolet filter that passes all visible wavelengths of light with minimal absorption, no aberration, and no noticeable internal reflections. Fully Multi-Coated.

5-9.25" SCT / Mak – $39.95 • Meade 10/12/14" – $89.95 • Celestron 11/14" – $89.95

LUMICON COMET BAND FILTER

Lumicon's narrow visible bandpass (25nm) Comet Band Filter isolates the 501nm OIII and the Cyanogen lines at 511nm and 514nm. The high contrast gain of the filter reveals the delicate ionized tail of gaseous comets, allowing you to see their full extent. The Comet Band Filter also helps you to better distinguish gaseous comets from dusty comets which show little contrast gain. For dusty comets, use the **Lumicon Deep Sky Filter**.

Howard Brewington, famed comet discoverer says: "I discovered Comet Aarseth-Brewington, 1989a1, using the Lumicon Comet Band Filter. The filter doubled the contrast, making the comet very easy to spot." Be the person to discover the next "Comet of the Century" using the Lumicon Comet Band Filter.

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back – $199.95

SOLAR PROMINENCE FILTERS

The 1.5 Ang. Lumicon Solar Prominence Filter system lets you see the awe-inspiring solar prominences jutting from the edge of the sun. Sunspots and bright filaments can also be seen on the sun's surface. The filter has a 2" barrel for insertion into 2" focusers, and can be easily adapted for 1.25". It also has camera T-threads and a viewing adapter for 1.25" eyepieces.

Solar Prominence Filter $699.95 • 58mm Energy Rejection Prefilter – $169.95 • 77mm Energy Rejection Prefilter – $199.95

Off-Axis Mask for 8" SCT – $69.95 • Off-Axis Mask for Meade 10" – $89.95 • Off-Axis Mask for C11 – $99.95 • Off-Axis Mask for 12" LX200 – $99.95 • Off-Axis Mask for C14 – $119.95 • Off-Axis Mask for M14 – $119.95 • Off-Axis Mask for 16" LX200 – $129.95

MULTIPLE FILTER SELECTOR

The Lumicon 1.25" Multiple Filter Selector lets you switch instantly back and forth between your Lumicon 1.25" filters without having to constantly thread and unthread them from your eyepieces. You may leave one of the 5 slots open to compare filtered and unfiltered views.
– $129.95

EASY GUIDERS

All of Lumicon's famous off-axis guiders feature Lumicon's patented radial and rotational off-axis adjustments – combined with a large off-axis pick-off prism, making bright guide star selection a breeze.

CASSEGRAIN EASY GUIDER FOR 7" TO 9.25" SCTs

The Lumicon Cassegrain Easy Guider allows off-axis guiding with your Cassegrain telescope while reducing the f-ratio from f/10 to f/6.3 using a large, fully-coated focal reducing lens. The faster f-ratio, combined with the ease of finding and guiding on bright guide stars, minimizes guiding error, making for successful astrophotos. Threaded for 48mm filters. Specify camera type when ordering.

Celestron 5 – $249.95 • 7" Mak – $249.95 • 8" SCTs – $249.95 • Celestron 9.25" – $249.95

GIANT EASY GUIDER FOR 10" TO 16" SCTs

The Lumicon Giant Easy-Guider is a powerful photo/visual tool, utilizing an 80mm multicoated compression lens to reduce your Schmidt-Cassegrain's f/10 optics to f/6.3 for wide-angle photography. Ideal for 35mm and 120 format film with 100% edge-to-edge illumination and pinpoint star images. All other off-axis guiders have prisms and focal reducing lenses a fraction the size of the Lumicon Giant Easy Guider's. Threaded for all Lumicon 48mm filters. Specify camera type when ordering.

10", 12", 14" and 16" Meade – $399.95 (Meade 16" LX200 requires adapter - $169.95) • 11" and 14" Celestron – $399.95

NEWTONIAN AND REFRACTOR EASY GUIDER

The Lumicon Newtonian and Refractor Easy Guiders allow off-axis guiding directly through the main telescope, thus preventing differential flexure between telescope and guide scope that can ruin your astrophotos. Low-profile design installs in seconds into 1.25" and 2" focusers. Threaded for 1.25" and 48mm filters. Specify camera type when ordering.

1.25" and 2" Newtonian – $189.95 • 1.25" and 2" Refractor – $189.95

LUMICON EASY GUIDER ACCESSORIES

- Newtonian Easy-Guider Focal Reducer Lens in Cell – $79.95
- Giant Easy-Guider Focal Reducer Lens in Cell – $199.95
- Giant Easy-Guider - No Lens – $319.95
- Cassegrain Easy-Guider - No Lens – $219.95

LUMICON 3X RELAY DIAGONAL FOR USE WITH EASY GUIDERS

Lumicon Relay Diagonal's 3x Barlow lens increases the guiding magnification in the off-axis portion of your Lumicon Easy-Guider, increasing off-axis guiding ease and precision. – $99.95

HYPER KITS

LUMICON FILM HYPERSENSITIZATION KITS

Film hypersensitization with a Lumicon Hyper-Kit super-dries your film's emulsion using nitrogen and hydrogen (Lumicon's Forming Gas: 8% prepurified hydrogen, 92% prep. nitrogen, removing ALL water vapor and oxygen molecules, thus thermally stabilizing the film's emulsion. The process also 'soaks' the emulsion with hydrogen, thus sensitizing the silver halide crystals, making them more sensitive to faint light. The combined effect reduces reciprocity failure of the film, allowing it to remain sensitive to light well beyond an hour instead of only a few minutes. Hypered film is a MUST for anyone who is serious about taking deep-sky photographs.

LUMICON MODEL 300 FILM HYPERSENSITIZATION KIT FOR 35MM AND 120 FILM

For simplest hypering with film still in its metal cassette, the Model 300 Hyper-Kit is easy in use and safe for your film. Operates with Lumicon's Forming gas at 30° C. Hypers film in two to five days.

Chamber Only – $249.95 • Film Hyper Kit – $375.95 • Hyper Kit O-Ring Set – $9.95

LUMICON MODEL 600 FILM HYPERSENSITIZATION KIT FOR 35MM AND 120 FILM

The versatile Lumicon Model 600 Hyper-Kit is capable of hypering film either while still in its metal cassette at 30° C, or more quickly with highest saturation on the open reel at 50° C. Super-dries and sensitizes the film's emulsion with Lumicon's Forming Gas.

Chamber Only – $299.95 • Film Hyper Kit – $475.95 • Hyper Kit O-Ring Set – $9.95 • Hyper Kit Hand Vacuum Pump – $39.95 • Hyper Kit Vacuum Pump Handle – $9.95

LUMICON MODEL 1200 FILM HYPERSENSITIZATION KIT FOR 35MM, 120, AND 4x5 FILM

Large-capacity Lumicon Model 1200 Hyper-Kit accepts 4x5 film. Kit is capable of hypering film in just 12-to-20 hours with highest saturation. Super-dries and sensitizes the film's emulsion with Lumicon's Forming Gas at either 30° or 50° Centigrade for simple or advanced modes of operation.

Chamber Only – $379.95 • Film Hyper Kit – $751.95 • 4x5 Plate Holders – $99.95 • Hyper Kit O-Ring Set – $9.95

HYPER KIT ACCESSORIES

- 4x5 Sheet Film holder – $99.95
- 35L Cylinder of Forming Gas – $145.95
- 30° C Temperature Sensor Probe – $99.95
- 50° C Temperature Sensor Probe – $99.95
- Temperature Controller – $139.95 • Electric Vacuum Pump – $349.95 • 220 V option on Vacuum Pump – $44.95 • 220V/110V Converter – $29.95 • Vac/Pressure Hose with Clamp – $9.95

ASTROPHOTOGRAPHY FILM

HYPERED FILMS

Use Lumicon Hypersensitized Film to take stunning astro photographs. *Allows you to* expose film on your favorite deep sky object far longer, with no fog buildup, than does non-hypersensitized film.

Fuji G800 – $19.95 • Fuji RD100 – $14.95 • TP2415 B&W – $19.95 • TP6415, 120 – $19.95 • Kodak P1600 – $24.95

NON-HYPERED FILM

Lumicon's high-contrast, extremely fine-grained film. High quality for medium-format astrophotography.

TP2415, Bulk 150' Roll – $79.95 • TP2415, Normal 36 exposure – $11.95 • TP4415, 4x5" Normal 25 Sheets – $49.95 • SO-279 Vericolor Slide Film – $14.95 • Kodak 6415, Normal Film – $9.95 • Fuji G800, Normal Film – $9.95 • Kodak P1600, Normal Film – $19.95 • Fuji Sensia RD100, Normal Film – $9.95

FILM DEVELOPING MATERIALS

- Film Changing Bag – $ 16.95
- Kodak D19 B&W Developer – $ 19.95
- Patterson film developing tank – $19.95

DIAGONALS

ENHANCED ALUMINUM STAR DIAGONALS

The Lumicon Enhanced Aluminum Star Diagonal reflects 96 to 97 percent of the light from the telescope's primary optics into your eyepiece. Its single 1/10 wave precision-polished surface is superior to the three surfaces of prism diagonals, and its enhanced coating is more durable than a standard aluminum coating. Lumicon collimates each star diagonal using a double-pass collimator, ensuring that the light reflected from the diagonal is perfectly perpendicular to the telescope's optical axis. 1.25" – $99.95 • 2" – $189.95 includes 1.25" adapter.

LUMIBRITE STAR DIAGONAL

The Lumicon Lumi-Brite Dielectric-Coated Diagonal reflects >98 percent of the light from the telescope's primary optics into your eyepiece. Not only is the Dielectric Coating more durable than a standard aluminum coating, it is also smoother, resulting in higher image contrast. 1.25" – $149.95 • 2" – $239.95 includes 1.25" adapter

SKY VECTOR

The Lumicon Sky Vector is a state-of-the-art digital setting circle system, providing virtually any astronomical telescope, whether equatorial or altazimuth, with a continuous, real-time digital readout of right ascension and declination coordinates. With the Sky Vector, you will be able to find objects even faster than with most fully computer-driven telescopes. Its alphanumeric display uses a simple, easy-to-read scrolling text format. There is no need to polar align or to enter Latitude, Longitude, Date, Altitude, and Sidereal time – just initialize on one or two stars and you're ready to go!

SKY VECTOR 1

The Lumicon Sky Vector 1 features: One- or two-star initialization; 4000-step encoders for high-resolution accuracy (0.09 deg.); Digital Right Ascension coordinate readout to 1 minute; Digital Declination readout to 10 arc-minutes; Guide mode for guiding you to the selected object in current memory; Database containing over 220 of the finest objects in the sky, including the popular "Messier Catalog."

Complete Set – $349.95 • Kit only – $269.95

LUMICON NGC SKY VECTOR

The Lumicon NGC Sky Vector has all the features of the Sky Vector 1, plus a large 12,000-object database, higher resolution display modes, IDENTIFY mode, and current constellation and chart number displays - all on a 16-digit red LED display. It can be integrated with a personal computer for display of celestial object coordinates.

Complete Set – $489.95 • Kit only – $419.95 • Serial Cable – $29.95

SKY VECTOR UPGRADES

- Upgrade 3.65 Chip Set for NGC Sky Vector. – $59.95
- 8192-Step Encoder Set. Can be purchased separately or in place of the standard 4000 step encoders. – $29.95

LUMICON SKY VECTOR HARDWARE PACKAGES

Lumicon Sky Vector Hardware Package for Meade and Celestron SCTs includes: declination encoder bracket, right ascension encoder holder, encoder shaft holders, Allen wrench, and instructions.

Lumicon Sky Vector Hardware Package for Dobsonian telescopes includes: brass azimuth bolt, stainless steel azimuth encoder bracket, aluminum altitude-encoder-shaft holder, stainless steel altitude encoder bracket, 10 wood screws, Allen wrench, and instructions.

C5+ – $79.95 • C8 – $69.95 • Celestar 8 – $79.95 • Celestar 8 Dlx – $79.95 • G8/G11 – $349.95 • Ultima 8 – $79.95 • Ultima 11 – $99.95 • C11 – $79.95 • C14 – $129.95 • Meade 2080 – $69.95 • 2120 – $79.95 • 8" Dob – $69.95 • 10" Dob – $69.95 • 12/13" Dob – $79.95 • 16/17" Dob – $89.95 • CI700 – $299.95

RICHFIELD VIEWERS

RICHFIELD VIEWER FOR 7" TO 9.25" SCTs

The Lumicon Richfield Viewer takes your Schmidt-Cassegrain's f/10 optics and reduces them to f/6.3 for beautiful wide-field views. Its fully-coated 50mm diameter focal reducing lens has a larger clear aperture and less coma than higher-priced focal reducers on the market, providing superb unvignetted views. Barrel accepts 2" star diagonals. Comes with an aluminum 2" - 1.25" eyepiece reducer, threaded for 48mm filters. – $99.95

RICHFIELD VIEWER, THREADED FOR 7" TO 9.25" SCTs

Threads directly into telescope. – $99.95

RICHFIELD VIEWER, SLIDE-ON, FOR 7" TO 9.25" SCTs

For attachment onto SCTs that have the Lumicon Easy-Guider threaded attachment ring in place. Slides over attachment ring. – $99.95

GIANT RICH-FIELD VIEWERS

LUMICON GIANT RICH-FIELD VIEWER FOR LARGE SCTs

Takes your large Schmidt-Cassegrain f/10 optics and reduces them to f/6.5 for the widest possible views of large galaxies like M31, M33 and NGC 253, and pairs of galaxies like M81 and M82. Moving the 80mm diameter focal reducing lens to the forward position in the Rich-Field Viewer body yields an even wider field. Comes with a 2" - 1.25" eyepiece reducer, threaded for 48mm filters.

10" SCTs – $279.95 • Celestron 11" – $279.95 • 12" SCTs – $279.95

LUMICON 2.5X CCD COMPRESSOR

This cost-effective, fully-coated lens widens the telescope field and yields pinpoint star images for small to medium-size CCD cameras. Has male threads for standard 1.25" eyepieces or camera-type barrels. – $129.95

LUMICON 48MM COMA CORRECTOR FOR NEWTONIAN EASY GUIDER OR 2" EYEPIECE

The Lumicon Coma Corrector lens dramatically reduces coma when used, in particular, with f/3.5 to f/6 Newtonian telescopes. It makes off-axis star images much smaller, thus improving photographic quality and making guiding much easier. Free of all chromatic aberration and fully multicoated to prevent ghost images. Can be used on all 48mm threaded accessories. Neither shrinks nor magnifies the image. – $239.95

LUMICON 1.5x–1.8x MULTIPLIER/FIELD FLATTENER

The Lumicon Multiplier / Field Flattener Lens has been custom computer-designed to increase image scale with the flattest field possible for photography and visual use with fast Newtonian Telescopes. This lens is suitable for use with f/3.5 to f/6 systems. Fully multicoated for maximum light transmission. – $259.95

FINDERSCOPE

Lumicon 80mm SuperFinder for Right-Angle viewing. This finder telescope actually lets you see many of the deep-sky objects you are looking for, complementing any telescope having 8 or more inches of aperture. It also makes for a wonderful rich-field telescope for beautiful views of the Milky Way. Comes with 25mm, 1.25" cross-hair eyepiece and helical drawtube-type focuser.

50mm RA Finder - Body Only – $79.95 • 50mm RA Finder - Complete – $149.95 • 50mm Straight-Thru Finder - Body Only – $79.95 • 50mm Straight-Thru Finder - Complete – $119.95 • 80mm Right Angle SuperFinder - Body Only – $199.95 • 80mm Right Angle SuperFinder with Tripod Block – $219.95 • 80mm Right Angle SuperFinder - Complete – $299.95 • 80mm Straight-Thru SuperFinder - Body Only – $199.95

FINDERSCOPE BRACKETS

This two-ring finder bracket firmly holds finderscopes to your telescope while allowing precise alignment with the main optical axis. The base is radius-cut to fit snugly against the telescope's main tube, and the dovetail groove makes it easy to install or remove the finderscope from the base. Fastens in brand name SCT telescope mounting holes.

- 50mm Finder Bracket, 8", 10/11", and 14" – $49.95
- 80mm Finder Bracket, 8", 10/11", and 14" – $59.95

- Universal Dovetail Bracket for 50mm finder – $39.95
- 2 traditional universal ring-type brackets for 50mm finder – $19.95

LUMICON 25MM CROSS-HAIR FINDERSCOPE EYEPIECE

This well-made 25mm, 1.25" Kellner single-crosshair finderscope eyepiece is ideally suited for Lumicon's 50mm and 80mm SuperFinders. High contrast and flat field. Non-illuminated. – $69.95

GUIDING EYEPIECE

LUMICON GUIDING EYEPIECE WITH RETICLE ILLUMINATOR

Lumicon's top-quality 12.5mm, 1.25" Orthoscopic eyepiece with focusable dual cross hair for precision guiding. Incorporates new state-of-the-art cordless Reticle Illuminator, featuring rheostatic brightness control and on/off switch.

12.5mm, 1.25" Illuminated Reticle Eyepiece. – $149.95 • Pulseguider Illuminator – $42.95

BINOVIEWER

LUMICON BINOVIEWER

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LOCATION, LOCATION, LOCATION are the three main factors in star cluster M67's long life. Its place on the fringes of the Milky Way has kept it out of the path of destructive clouds of gas and dust for nearly 5 billion years.

LICAI DENG AND THE BEIJING-ARIZONA-TAIPEI-CONNECTICUT TEAM AT BEIJING ASTRONOMICAL OBSERVATORY

M67: *the* ULTIMATE SURVIVOR

Marauding interstellar clouds eat star clusters like M67 for breakfast. Find out how this ancient object has cheated death for nearly 5 billion years. /// BY KEN CROSWELL

AN OPEN STAR CLUSTER LIKE THE BEEHIVE (M44) IN CANCER SPRINKLES space with glowing gems, but the cluster itself faces a harsh future. Giant blobs of gas and dust called molecular clouds, some wielding more than a hundred thousand times more mass than the Sun, roam the Milky Way. Their gravity can tear a cluster asunder. Chances are, a billion years from now, the Beehive won't exist.

Yet the same constellation features an open star cluster that has survived about as long as the 4.6-billion-year-old Sun (see "Celestial Portraits" on page 76). The cluster, called M67, is 2,800 light-years from Earth, so the light you see from its stars tonight was already en route to us when the Greek philosopher Plato was born. Because of M67's age, astronomers often observe its stars to study stars as old as the Sun.

They don't have many other choices. Astronomers have cataloged some 1,200 open star clusters in the Milky Way, but those older than a billion years number just a few dozen. Those older than the Sun number even fewer. That's how relentlessly giant molecular clouds rip these clusters apart.

M67, however, is well positioned to survive — literally. It resides in the outer galaxy, where giant cluster-shredding molecular clouds are rare. The Sun is 27,000 light-years away from the Milky Way's center — about halfway from the center to the edge of the stellar disk — whereas M67 is 29,000 light-years away from the galaxy's heart.

Most giant molecular clouds inhabit the inner galaxy. Thus, star clusters like M67 are able to dodge these deadly objects. Indeed, of the twenty or so open clusters that exceed the Sun's age, 90 percent dwell in the outer Milky Way.

Furthermore, M67 hovers 1,400 light-years north of the galaxy's plane. This distance between the cluster and the galactic plane protects M67 because the plane harbors the giant molecular clouds. Like all the Milky Way's objects, M67 bobs up and down on its orbit around the galactic center. It passes through the galactic plane like a horse on a merry-go-round, but it spends most of its time above or below the danger zone. In contrast, the Sun never strays farther than 250 light-years from the plane.

Still, M67 surely has lost stars. The most vulnerable are the smallest — the red and brown dwarfs. As M67's stars orbit the cluster's center, they exchange energy with one another in a way that equalizes each star's energy of movement, or kinetic energy. Because this energy depends on a star's mass and velocity, the more massive stars slow down and sink toward M67's center. The less massive ones can speed up so much they escape from the cluster.

While the image spans about 45 light-years from top to bottom, most of M67's mass lies within a dozen light-years of its center. Any star that strays more than 30 light-years away from the cluster's heart may never return, and indeed, a star leaves the cluster once every few million years. Most of M67's original red dwarfs probably are gone.

Nevertheless, the overall cluster survives, still boasting more than a thousand stars. Blessed by its birth in the outer Milky Way and its perch far from the galactic plane, M67 must have witnessed the destruction of countless other star clusters. Chances are, a billion years hence, M67 will be shining still, occasionally shedding a small red star into the galaxy at large.

Ken Croswell *earned his doctorate in astronomy at Harvard University and is the author of* Magnificent Universe *and* Magnificent Mars.

To learn more about M67 and similar veteran star clusters, visit www.astronomy.com/toc

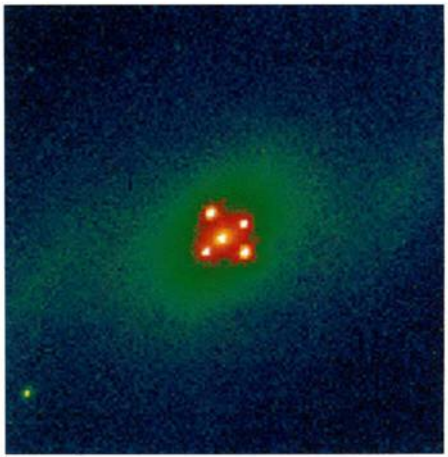
ASK ASTRO

Gravity lenses, defining a planet

GRAVITY LENSES

I noticed that the photo of Einstein's Cross on page 47 in the November 2003 issue shows four images. Why aren't there many more, even a circle of images, because the light from the source would be going in all directions?

— **TOM SCHMIDT,** FLORISSANT, MISSOURI



IT'S ONLY ONE QUASAR, so why are there four images? A gravitational lens usually produces multiple images (as seen here with the Einstein Cross) instead of a smooth ring because the distant object, the lensing mass, and Earth do not align precisely. STScI

The French term *mirage gravitationel* comes closer to describing the effects of an intervening galaxy on the light from a background quasar than the English term "gravitational lens."

In a terrestrial mirage, we see two (or more) images of an object. In physics, Fermat's principle tells us that light rays must travel along paths for which the light travel time is a minimum, a maximum, or something called a saddlepoint, which represents a place that appears like a maximum from one viewpoint and a minimum from another.

With mirages on Earth, variations in the index of refraction of air (caused by temperature changes and layering in the air) sometimes permit us to see two images because each path is one of the cases mentioned above. Objects with rough surfaces reflect light in all directions, but we see only two images because only two paths have the special property of being a maximum or a minimum, for example. Thus each image is formed from light traveling one of these paths.

In the gravitational case, the gravity of the lensing galaxy acts like the index of refraction of air. It slows down the light as it travels past the galaxy. If the quasar (which we take to be pointlike) aligns sufficiently closely with the galaxy, a second image appears. If the quasar aligns *very* closely, we get four images.

In principle, we might see a perfect ring if the two objects were aligned exactly, but the galaxy would need to be perfectly circular. If the galaxy is the slightest bit elliptical, symmetry is broken and four images result instead.

If the source is extended on the sky and not pointlike, then we may get a ring — as long as the source's deviations from circularity are small. In such cases, different parts of the ring are images of slightly different parts of the source. Typically, a single part of the source can be found four times in the ring. — **PAUL SCHECHTER,** MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DEFINING A PLANET

How do you differentiate between a star, a planet, and a moon?

— **LIEW KONG YEE**

On the big end, the answer is pretty easy. Stars are gaseous bodies that generate heat and radiation through nuclear fusion. Planets, asteroids, comets, and moons are solid objects that don't. The situation gets more complicated, however, when you try to draw a line between planets and smaller bodies, or between planets and moons.

To start, let's restrict the discussion to the lower boundary of planetdom. Then the question becomes: Is Pluto a planet? As one of the self-appointed experts on this topic, I have a simple answer — yes, Pluto's a planet. That's the good news, and perhaps I should stop here. But I can't resist telling you the bad news. Being a planet, as I define it, does *not* mean what most people think it means, and some professional astronomers would call me nuts for saying Pluto's a planet. Indeed, this has been a surprisingly divisive question recently.

The question of what is a planet is a semantic one, and for reasons I don't have room to explain, a politically charged one. Being a semantic issue means that we can do what we want. We can simply declare that there are nine planets, period. Or we can say any object in orbit about the Sun with a diameter larger than 1,460 miles (2,350 kilometers) is a planet. (Pluto's diameter is about 2,360 km.) Both definitions give us the nine classical planets.

However, it's not possible to develop a *physically meaningful* definition that leads to nine, and only nine, planets. I can think of definitions that say there are eight planets (guess which one isn't included), or ones in which there are roughly twenty planets. The problem is that nobody has come up with a definition that includes Pluto while excluding large asteroids like Ceres and Vesta.

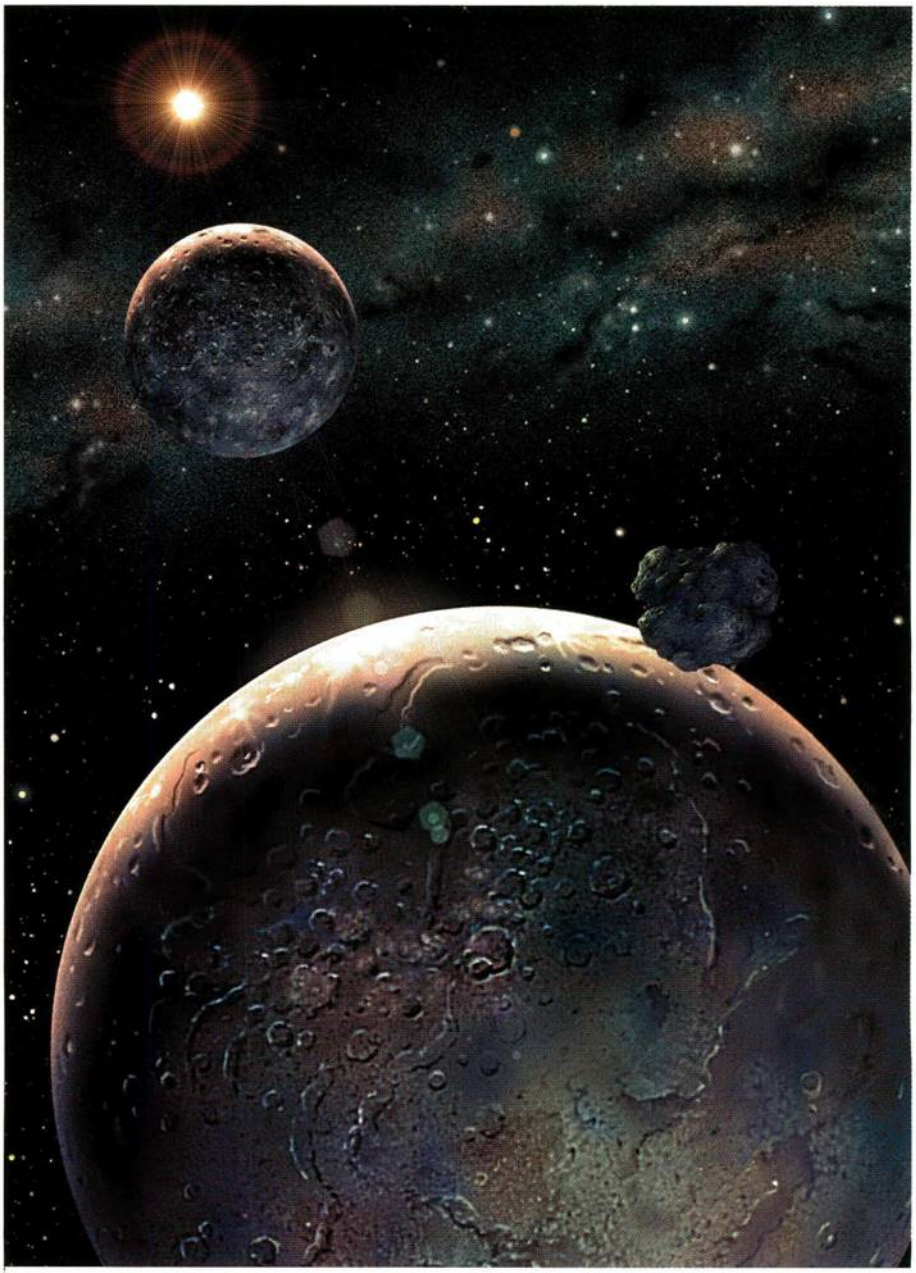
Alan Stern (principal investigator for NASA's New Horizons mission to Pluto) and I, who originally were on different sides of the Pluto question, got together a couple years ago and developed a compromise. It has two parts. First, we define a planet as anything that goes around a star and is big enough so that gravity makes it roughly round. In the solar system, this includes the nine classic planets. But it also includes many of the larger asteroids and Kuiper Belt objects (Pluto's icy cohorts orbiting beyond Neptune). These include Ceres, Pallas, Quaoar, Ixion, Varuna, and many others that few people have heard of.

We then divided the planets into two groups. Planets large enough to clear their neighborhood of small objects we called "über-planets." Those still embedded in a swarm of small objects we labeled "unter-planets." (We could have used "major" and "minor," but that would not have been politically correct.) Thus, we have eight über-planets and a large number of unter-planets. But at least Pluto is a planet, albeit an unter-planet.

Now, there is one sticky problem that Alan and I swept under the rug. What does "go around a star" mean? In most cases, it's obvious. For example, although Jupiter's moon Ganymede (with a diameter of 3,275 miles, or 5,270 km) is much larger than Pluto, it clearly goes around Jupiter and, thus, is not a planet. But there are two places in the solar system where the distinction isn't clear. The first is — surprise — Pluto. Pluto's moon, Charon, is so large compared to Pluto (half its diameter) that rather than going around Pluto, Charon and Pluto both go around a point lying between them. So, in one sense, Pluto goes around Charon. Is Pluto then a planet? Or should we define them as a binary planet? Should we welcome Charon into The Planet Club? Probably.

The other place where the distinction gets dicey is right here at home. Like all objects in orbit around the Sun, the Moon is always falling toward the Sun (i.e., in technical terms, the Moon's orbit is always concave in a Sunward direction). This contrasts with the other major satellites in the solar system. In a real sense, therefore, the Moon is primarily going around the Sun, and Earth is a small perturbation on that motion. Another way of expressing this is that the Sun's gravitational pull on the Moon is nearly twice that of Earth's. So by all rights, the Moon should also be considered a planet!

Well, the list of planets is getting longer and longer, and it's getting farther and farther from the standard picture of a solar system containing nine planets. So let me end by addressing one last question: Who cares? Well, not me, really. As I said above, this is a semantic issue. What's truly important is that each of these objects is a world with a personality of its own. And each tells us important information about how worlds work and how we came to be. This is where we should all focus our attention. — **HAL LEVISON,** SOUTHWEST RESEARCH INSTITUTE



IS PLUTO A PLANET? The status of Pluto's planethood depends more on verbal definitions than science — and it's not all that important anyway. DAVID HARDY

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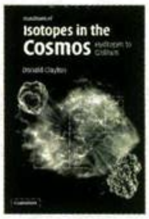

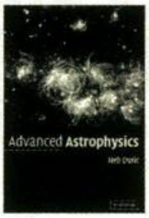

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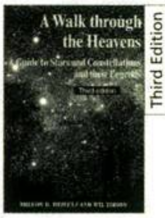

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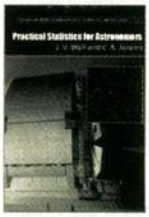

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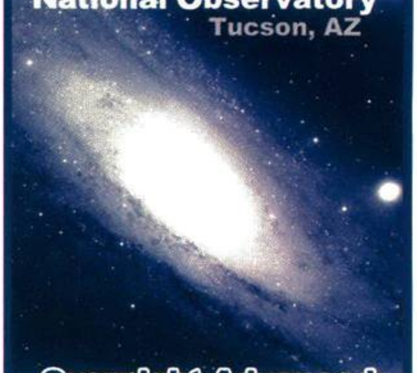

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Cancer, Leo, and Leo Minor

Springtime skies show off a bevy of galaxies in the constellations the Crab, the Lion, and the Little Lion. /// BY TOM POLAKIS

As spring arrives, the winter Milky Way yields to sparse star fields filled with galaxies. Following Gemini, Cancer the Crab is most easily seen as an upside-down Y shape. The first constellation to herald spring's arrival is Leo the Lion. Skywatchers can identify a prominent group of stars resembling a backward question mark dubbed the Sickle. At the base of this asterism sits Regulus, a blue-white gem of 1st magnitude located 80 light-years away. Lying on the ecliptic, Regulus often gets occulted by the Moon. Its angular size is diminutive, but occultation results have shown it to be about three times the diameter of the Sun. At the far end of a right triangle east of the Sickle lies Denebola, a 2nd-magnitude star only 36 light-years away. Leo Minor the Little Lion consists of an unassuming chain of four 4th-magnitude stars sandwiched between Leo and Ursa Major.

Our first target can be found by extending a line through Delta (δ) and Alpha (α) Cancri toward Hydra. **NGC 2775** is a bright spiral galaxy 60 million light-years away. Seen through an 8-inch telescope, it spans 3' by 2' and has a bright middle. Larger scopes begin to show some mottling halfway from the center to the edge produced by the galaxy's flocculent spiral structure. Two very faint companion galaxies, NGC 2773 and NGC 2777, appear to the north in the same medium-power field. NGC 2777 is a true companion, but NGC 2773 lies four times as far away and isn't associated with the others.

M67 (NGC 2682) comes into view after panning almost 2° west of Alpha Cancri. Astronomers estimate M67 is 4 billion years old, making it an exceptionally old open cluster. (See "M67: the Ultimate Survivor" on page 70.) As such, it holds great value for teaching us about the evolution of the Milky Way's disk. A medium-size reflector reveals 60 stars evenly distributed across a 20' diameter. A dozen of its stars glow brighter than 11th magnitude, and the star density picks up considerably beyond 13th magnitude. As a result, more than 100 stars and a background haze become apparent in large apertures. Look for a yellow, 7th-magnitude, nonmember star at the cluster's eastern edge.

Tom Polakis, *an aerospace engineer from Arizona, has penned all 45 articles in our Celestial Portraits series, which began as "Deep-Sky Splendors" in the April 1998 issue.*

TWO OPEN CLUSTERS, M67 (bottom) and M44, highlight Cancer the Crab. PETER LEDLIE

At a distance of 600 light-years, **M44 (NGC 2632)** is the fifth-nearest star cluster to Earth. Member stars shine as bright as magnitude 6, so the Beehive Cluster, as it's called, offers something for even the smallest scopes. To the unaided eye, it looks like a tiny, uniform haze against a decidedly starless backdrop. Binoculars show 15 stars across a 1° field. Look for a V-shaped asterism formed by the brightest stars at the center. A rich-field scope will reveal about 40 stars. The view does not improve much above an aperture of 8 inches, as the field becomes too small for the cluster aspect to be apparent.

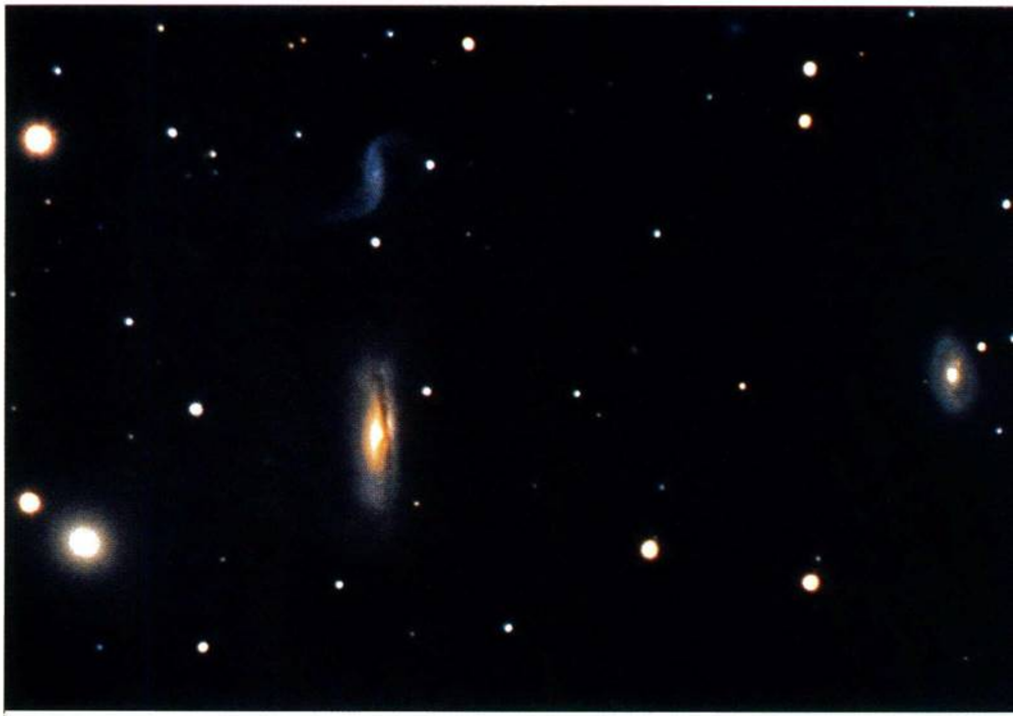
Begin exploring Leo at the northern end of the Sickle. Easily found by dropping 1.5° south of Lambda (λ) Leonis, **NGC 2903** provides a bright example of a "hotspot" galaxy 28 million light-years away. This term was first used in 1958 to describe a ring of luminous knots near the core of a galaxy, which modern instruments show to be young star clusters. A

10-inch telescope shows a halo measuring 4' by 2' surrounding a bright core. Indicative of a spiral structure, a bar featuring symmetrically placed enhancements emanates from the galaxy's center. Under high magnification, spiral arms that are only slightly brighter than the outer halo begin to show up.

Leo I is a dwarf spheroidal galaxy that's easy to locate but not easy to see due to glare from Regulus, which lies less than half a degree to the south. At a dark site with an 8-inch scope at moderate magnification, the faint mist of Leo I appears about 8' by 6' and uniformly bright. High magnification spreads the galaxy's light out too much, and too little magnification invariably puts the 1st-magnitude star in the field. While not spectacular telescopically, Leo I is a visible example of a companion dwarf galaxy — one of only ten associated with the Milky Way. It was discovered in 1950 on plates from the Palomar Sky Survey, which resolved the galaxy's stars. Don't expect to glimpse them visually, however, as the brightest members glow faintly at 19th magnitude.

Staying in the Sickle, we turn next to a pretty binary star. **Algieba**, or Gamma (γ) Leonis, resolves easily at 100x in small telescopes. Look for the 4th-magnitude secondary just over 4" east-southeast of the primary. The two stars currently are separated by their maximum extent, and with an orbital period of over 600 years, they won't change noticeably in separation or position angle during this century.

Midway between Algieba and Zeta (ζ) Leonis lies a small group of four galaxies centered on **NGC 3190**. Known as Hickson 44, the group is the brightest in Paul Hickson's catalog of 100 compact galaxy groups and is situated 70 million light-years away. NGC 3190, the brightest galaxy in the group, shows up as an oval haze 3' long with a very bright core. Large telescopes begin to bring out the dust lane south of the nucleus. The other bright galaxy in the group, the elliptical NGC 3193, lies 6' to the northeast. It appears nearly 2' across with a bright center and a 10th-magnitude star at the northern edge. The much fainter, barred spiral NGC 3185, which shows up as a dim, 2' circular haze with little concentration, resides 11' south-southwest of NGC 3190. Rounding out the quartet is the tidally disrupted spiral NGC 3187, a challenging visual object.


THE NGC 3190 GROUP includes four distinct galaxies. NGC 3190 is the brightest member of this quartet. It's joined by NGC 3193 (left), hooked NGC 3187 (top) and barred NGC 3185 (right). JAMES FOSTER

Return to Algieba and pan 1° east to find an interacting galaxy pair dominated by the inclined spiral **NGC 3227**. The elliptical galaxy NGC 3226 appears to be attached to the northern end of the brighter galaxy. Telescopically, NGC 3227 looks like a bright oval that's 2' long and sharply concentrated. Its outer halo has an abrupt edge, and a 16-inch telescope begins to show the faint spiral arms that create this feature. With a similar surface brightness, NGC 3226 has a broad concentration and a very dim stellar core.

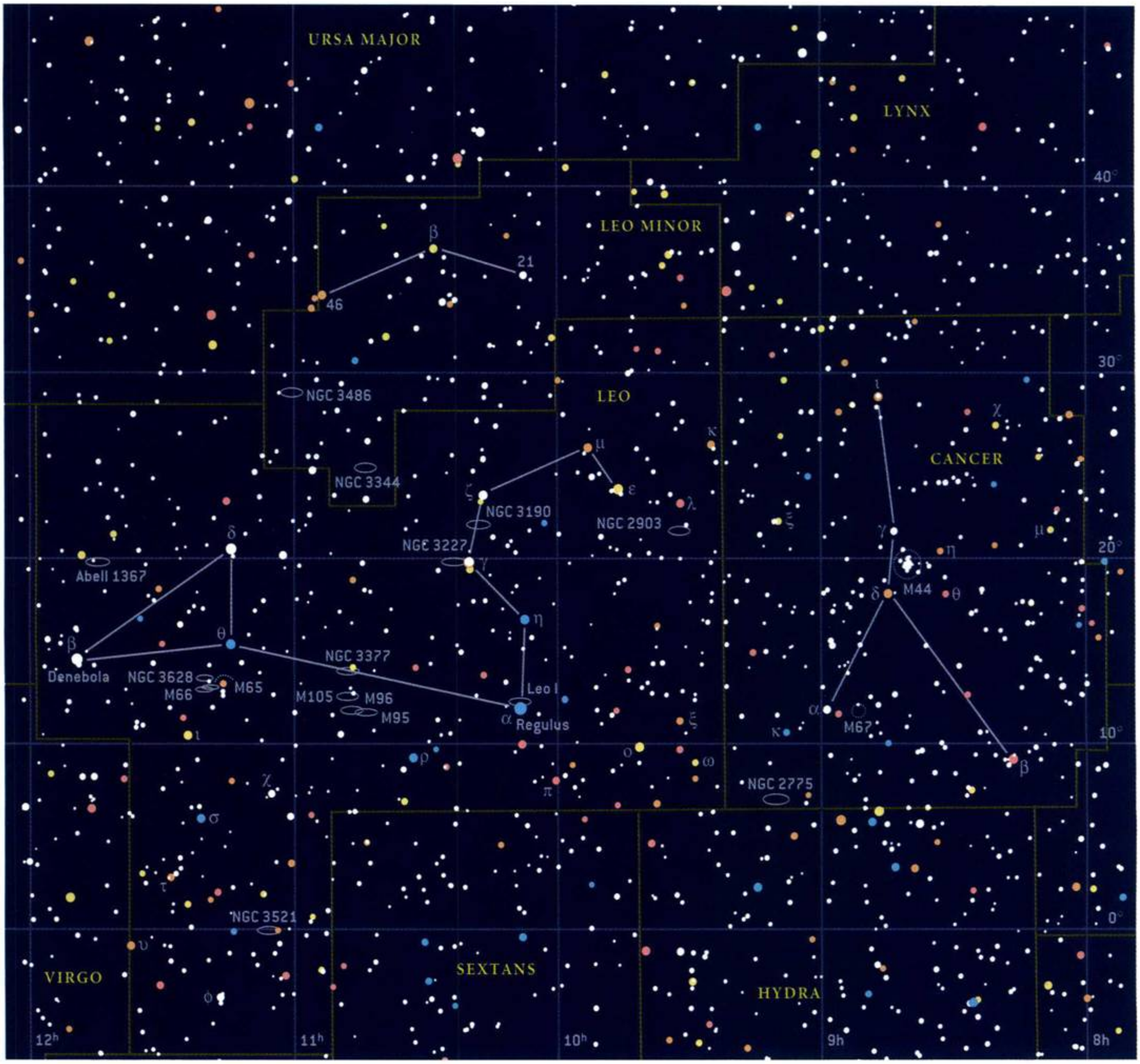
Drifting briefly into Leo Minor, we find the bright, face-on spiral **NGC 3344**. Telescopes as small as 12 inches in aperture reveal the spiral structure as a faint ring halfway between the core and the edge of the halo, which stretches across 4'. The core is strongly concentrated, appearing 20" across and very bright. Several field stars are superposed on the eastern half of the galaxy. NGC 3344 is unusually isolated for a bright galaxy; the nearest significant

/// CANCER, LEO, AND LEO MINOR

Beneath the stars, beside the unpausing flood,
Earth trembles at the wandering lion's roar;
Trembles again, when in blind thirst of blood
Sweep the wild tribes along the startled shore.
Gordon, *Ernest Myers (1844–1921)*

In Greek legend, there lived a lion whose skin could not be pierced by any weapon. In the first of his twelve labors, Hercules (or Heracles) confronted the beast, which resided in a double-mouthed cave near the town of Nemea, and strangled it to death. Hercules used the lion's own claws to cut off its skin, which he wore like a cloak. To commemorate Hercules's triumphs, the gods placed an image of the Nemean lion in the heavens.

Other ancient civilizations in Egypt and elsewhere also linked the constellation with the form of a lion. Each summer, African lions would migrate from the dry desert to the Nile Valley about the same time the Nile would flood. At this time, during the summer solstice, the Sun appeared in Leo, connecting the constellation, the lions, and the swollen river. Lions were used later as symbols on gates that opened irrigation canals in the Nile Valley and in fountains where water would spout from lions' mouths. Due to precession, though, the Sun is no longer in Leo during the summer solstice. — *Vanessa Thomas*


URSA MAJOR
LYNX
LEO MINOR
LEO
CANCER
VIRGO
SEXTANS
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β
21
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NGC 3486
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M66
M65
NGC 3377
M105
M96
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Leo I
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Regulus
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NGC 2775
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NGC 3521
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φ
40°
30°
20°
10°
0°
12h
11h
10h
9h
8h

galaxy, NGC 3274, lies some 1.5 million light-years away from it.

Farther north sits **NGC 3486**, an Sc spiral galaxy characterized by short arms in a poorly defined pattern. This structure turns up in an 8-inch scope as mottling in the outer halo. A broadly concentrated disk makes up the inner 2' of the galaxy, but the patchy outer structure brings the galaxy's apparent size to 3'.

Returning to Leo, we spend some time in a nearby, bright group of galaxies. **M95 (NGC 3351)** belongs to the Leo I Group. Despite the confusing nomenclature, the group has nothing to do with the dwarf galaxy Leo I. The galaxy cluster lies 33 million light-years away and comprises nine galaxies in a region 4° across. M95 is an inclined barred spiral peppered with HII regions. It has a small circumnuclear ring 300 light-years thick. Through a 13-inch scope, M95 appears 5' across and slightly elongated with a bright center. At the edge of the halo, the spiral arms manifest themselves as a subtly brighter ring. Larger telescopes bring out a bar that crosses the center and ends at the ring.

At the eastern edge of a telescopic field showing M95 hovers the companion spiral galaxy **M96 (NGC 3368)**. It appears bright through backyard scopes, but detail is fleeting. A halo 4' by 2' holds an oval core with a bright nucleus. In 1998, a supernova in M96 reached magnitude 11.9.

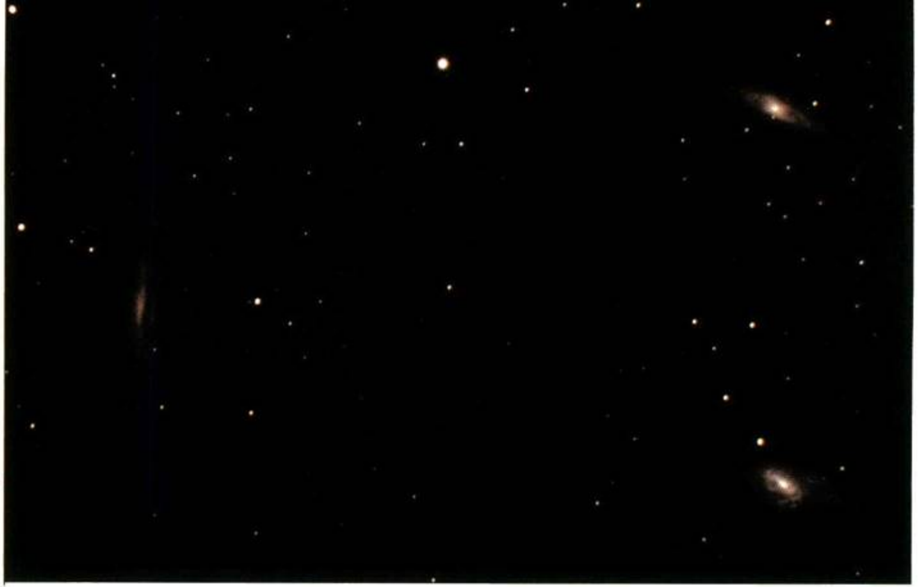
Less than 1° north of M96 lies another bright galaxy associated with M95 and M96. Owing to its proximity to us, **M105 (NGC 3379)** is one of the best-studied elliptical galaxies. Astronomers have found 150 globular clusters in it. The galaxy exhibits a very bright, stellar core surrounded by a halo 4' by 3' across with an edge that's difficult to define. Look to the east to see two galaxies: Leo I Group member NGC 3384 and the more distant NGC 3389.

Next, pan 1.5° north to find **NGC 3377**, an elliptical galaxy displaying evidence of a central black hole of 100 million solar masses. Although bright telescopically, the galaxy isn't impressive, displaying a 4' by 2' haze around a bright nucleus.

A long, southward pan away from the Leo I Group toward the celestial equator reveals the bright spiral galaxy **NGC 3521**. At a distance of only 28 million light-years, it appears bright and detailed. In a 10-inch scope, it measures 5' by 2', showing a very bright core and a diffuse halo. Doubling the aperture increases the galaxy's apparent length to 7' and brings out fine spiral structure, particularly near the edge of the halo and along the minor axis near the core. NGC 3521 is inclined 30° from our line of sight.

Near the star Theta (θ) Leonis lie the bright galaxies of the Leo Triplet — a triangular group that fits into a 1° field. **M65 (NGC 3623)** anchors the southwestern corner. Inclined 15° from edge-on, it appears in modest telescopes as 2' wide and nearly four times as long. Spiral structure is difficult to discern, but signs of mottling exist near this galaxy's broad core.

Just to the east appears the more spectacular spiral **M66 (NGC 3627)**. A 12-inch telescope reveals a hint of the galaxy's spiral arms. Look first for a hook-shaped feature pointing northeast from the southern end of the bar. The corresponding feature at the northern end is more difficult to see. In this aperture, M66 measures 6' by 3'. In a larger telescope at a dark site, the spiral arms are plainly evident and dotted with stellar associations. In any scope, the edge of the galaxy appears well defined.



THE LEO TRIPLET forms a triangle of galaxies near the star Theta Leonis. Charles Messier cataloged the two on the right as M65 (top) and M66. The edge-on galaxy at left is NGC 3628. MARTIN BERNIER

Completing the Leo Triplet, **NGC 3628** glows more faintly than the two Messier objects. This edge-on starburst galaxy resembles M82; even a casual look at its deformed appearance suggests tidal interaction. Further scrutiny has revealed an encounter with M66 that took place 800 million years ago, when the two galaxies were only 80,000 light-years apart. NGC 3628 appears in a 10-inch scope as 10' by 2' and shows a dust lane crossing south of the center that is not parallel with the long axis. In larger scopes, the faint tips of the galaxy look thicker than the center.

In the tail of Leo resides a distant galaxy cluster that's impressive for its angular size. Containing more than 100 galaxies, **Abell 1367** sprawls over a region nearly 2° in diameter. We view this cluster nearly edge-on, and its members lie 200 to 400 million light-years away from us. At this distance, the galaxies' light appears faint, but a couple dozen members are bright enough to earn NGC designations. For example, the centrally placed, nearly 1' glow of NGC 3842 shows up nicely through an 8-inch scope under dark skies.

Scanning the region at 200x with a 13-inch scope uncovers dozens of almost starlike galaxies. The region comes to life when viewed with very large scopes, where the view is reminiscent of the Hubble Space Telescope's deep-field exposures.

For more images and deep-sky targets, visit www.astronomy.com/toc

/// Deep-sky objects in Cancer, Leo, and Leo Minor

OBJECT	R. A.	DEC.	MAG.	SIZE/SEP.	TYPE	NOTES
M44 (NGC 2632)	8h40.4m	19°40'	3.1	95'	OC	Beehive Cluster
M67 (NGC 2682)	8h51.3m	11°50'	6.9	29'	OC	
NGC 2775	9h10.3m	7°02'	10.1	4.6' by 3.7'	Gal	SA(r)ab
NGC 2903	9h32.2m	21°30'	9.0	12.0' by 5.6'	Gal	SAB(rs)bc
Leo I	10h08.5m	12°18'	10.2	12.0' by 9.3'	Gal	E
NGC 3190	10h18.1m	21°50'	11.2	4.1' by 1.6'	Gal	SA(s)a pec
Gamma Leonis	10h20.0m	19°50'	2.3/3.5	4.4"	Dbl	Algieba
NGC 3227	10h23.5m	19°52'	10.3	6.9' by 5.4'	Gal	SAB(s)a pec
NGC 3344	10h43.5m	24°55'	9.9	6.9' by 6.4'	Gal	(R)SAB(r)bc
M95 (NGC 3351)	10h44.0m	11°42'	9.7	7.8' by 4.6'	Gal	SB(r)b
M96 (NGC 3368)	10h46.8m	11°49'	9.2	6.9' by 4.6'	Gal	SAB(rs)ab
NGC 3377	10h47.7m	13°59'	10.4	4.1' by 2.6'	Gal	E5
M105 (NGC 3379)	10h47.8m	12°35'	9.3	3.9' by 3.9'	Gal	E1
NGC 3486	11h00.4m	28°58'	10.5	6.6' by 4.7'	Gal	SAB(r)c
NGC 3521	11h05.8m	–0°02'	9.0	12.5' by 6.5'	Gal	SAB(rs)bc
M65 (NGC 3623)	11h18.9m	13°06'	9.3	8.7' by 2.2'	Gal	SAB(rs)a
NGC 3628	11h20.3m	13°35'	9.5	14.0' by 4.0'	Gal	Sb pec
M66 (NGC 3627)	11h20.3m	12°59'	8.9	8.2' by 3.9'	Gal	SAB(s)b
Abell 1367	11h44.5m	19°50'	—	100'	Gals	117 galaxies

Object: Designation in Messier, NGC, or other catalog. **R. A. and Dec.**: Right ascension and declination in epoch 2000.0 coordinates. **Mag.**: Visual magnitude. **Size/Sep.**: Size in arcminutes; separation in arcseconds. **Notes:** Hubble types for galaxies.

PROFILE

Dedicated amateur astronomer David W. Dunham has pioneered techniques for observing occultations for four decades. /// BY TRUDY E. BELL

Disappearing act

One clear, crisp, southern California evening in late October 1957, a lanky, sandy-haired, 15-year-old high school sophomore gazed intently through the eyepiece of a small refracting telescope at a setting Moon just a day shy of First Quarter. Audible in the background from a shortwave receiver was a steady ticking — one-second time signals broadcast by radio station WWV, a service of the National Bureau of Standards. The young man's gaze was fixed on the Moon's southern cusp, which was about to occult (pass in front of) Beta Capricorni, a widely spaced double star with a 3rd-magnitude primary and a fainter 6th-magnitude companion. Closer, closer, the Moon approached the pair of stars until — *wink*! The fainter companion silently disappeared from sight behind the Moon's dark limb. But the brighter star remained visible, skimming above the tops of illuminated lunar mountains until its fainter companion emerged from the glare several minutes later.

As the student watched, the Moon slowly moved away from the pair of stars, and he realized with frustration that had his telescope been set up several miles to the north of his observing location, he would have seen the brighter star grazed by the Moon's southern limb. Would he have seen the star flash off and on behind lunar mountains and valleys? Was it possible to predict where on Earth a person could see such a grazing lunar occultation?

That teenager was David W. Dunham. And, in the 1960s, those astute questions led the quiet-spoken but persistent young amateur astronomer to pioneer predicting grazing lunar occultations. In later decades, Dunham also began forecasting occultations of stars by distant asteroids in order to determine the sizes and shapes of those little-studied bodies.

THIS OCCULTATION OF SATURN took place on December 28, 2001. The Moon, moving eastward, had just uncovered the Ringed Planet.
CHRIS COOK

Now 61, Dunham serves as the longtime president of the International Occultation Timing Association (IOTA), which he founded nearly thirty years ago. IOTA distributes predictions to and collects observations from hundreds of observers worldwide who are dedicated to watching one celestial body block the light of another. Because of IOTA, timing occultations has taken its place alongside observing variable stars, charting meteors, measuring asteroid positions, and hunting comets as valuable scientific work for amateur astronomers. Indeed, for four decades Dunham himself has chased occultations around the globe, as his day job varied from map-making for the Air Force to calculating trajectories for interplanetary spacecraft for NASA (for example, guiding the Near Earth Asteroid Rendezvous-Shoemaker spacecraft in its pioneering landing on asteroid 433 Eros in 2001).

Chasing the Moon's edge

In the 1950s, scarcely anyone was predicting grazing lunar occultations or even seemed to be aware of either their existence or their scientific value. To be sure, astronomers had valued total occultations (as they later came to be called courtesy of Dunham as an analogy to total eclipses) for centuries. Before reliable chronometers or radio-based global positioning systems, ships' navigators, land surveyors, and explorers timed total occultations and compared their times to predicted times for known locations in order to determine their longitudes.

After seeing the Moon just barely miss two other stars in the autumn of 1961, Dunham began seeking a mathematical way to predict grazing lunar occultations. By then, he was a sophomore at the University of California at Berkeley, steeping himself in celestial mechanics. His big opportunity came on Sunday, March 11, 1962, when he calculated that the extreme southern edge of the six-day-old Moon was to occult Aldebaran, the brightest star in Taurus the Bull. Dunham's predictions showed the event might be seen as a graze somewhere in the San Francisco Bay area. After a marathon 36-hour session with a calculator and tables of logarithms and trigonometric functions, he computed six points on Earth for the predicted limit, or boundaries within which the event would be visible. Dunham's "graze line" fell 50 miles south of Berkeley. With barely an hour to spare, he scrambled to find an astronomy graduate student with a car, and the two raced against time with

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Trudy E. Bell *is managing editor of the* Journal of the Antique Telescope Society *and a journalist who has written several books and more than 250 articles about astronomy and technology.*

DAVID W. DUNHAM, the individual who galvanized U.S. amateur astronomers to observe grazing lunar occultations in the 1960s, is shown setting up for a grazing occultation. WILLIAM DUNHAM **IF THE TELESCOPE** isn't pointed at the right star, nothing will go right. Here (inset), Dunham adjusts his 5-inch Celestron Schmidt-Cassegrain telescope just prior to videotaping an occultation. WILLIAM DUNHAM

Dunham hanging his head out the passenger window staring at the star and the Moon. Unfortunately, time ran out, and he saw only a very short total occultation.

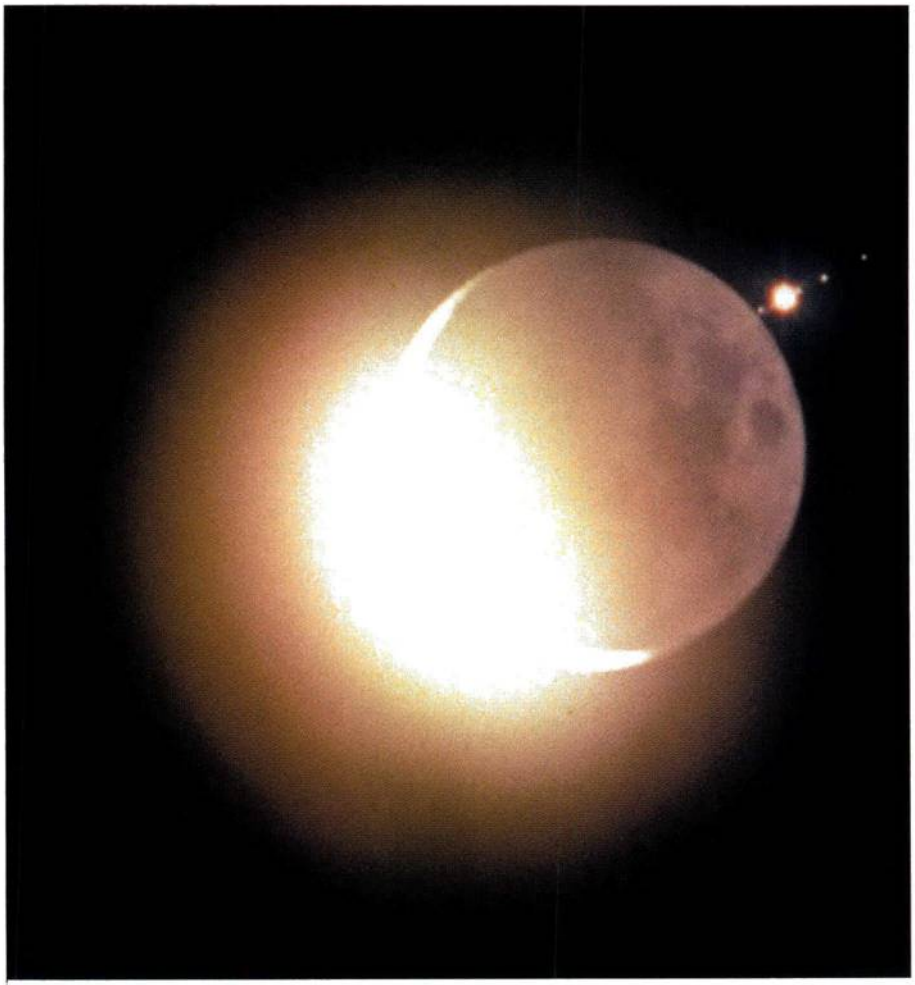
During the next six months, Dunham caught another short total occultation, which caused him to modify his mathematical technique. Several other opportunities to observe grazes were spoiled by clouds. Finally, on September 18, 1962, using Dunham's predictions, a friend from the Los Angeles Astronomical Society traveled 40 miles northwest of the city and observed 4.3-magnitude 5 Tauri flashing off and on several times along the Moon's southern limb — an historic first successful graze expedition.

By early 1963, Dunham had written and debugged a program for running graze calculations on a mainframe computer. Computerizing predictions saved effort and also allowed him to generate predictions for fainter stars and for other locations. This proved especially useful because as word spread among the amateur astronomy community about successful observations, requests for predictions from all over the world started arriving in his mailbox. That summer, to answer frequently-asked-questions, he wrote a two-page tip sheet called "Observing Grazing Occultations," which eventually begat successors with the same title and a Roman numeral marking its place in the series.

Throughout the 1960s, momentum built. Grazes were an amateur's dream — a brand new type of observation. They had scientific value, complementing total occultations as a way of accurately measuring the Moon's mountainous terrain. This was an important contribution to the Apollo program. Grazes also were accessible to the humblest telescopes. Indeed, because the Moon's shadow was cast life-sized on Earth, 2.4-inch refractors 0.1 mile apart could readily distinguish between features less than 500 feet apart on the Moon. This gave observers an effective resolution of 0.01 arcsecond — ten times better than the largest telescope on Earth.

From 1964 onward, Dunham's roster of observers and expedition leaders doubled each year. By 1968, Dunham was sending grazing occultation predictions to hundreds of individuals from dozens of countries on six continents. That same year, at its annual regional convention, the Western Amateur Astronomers awarded Dunham (by then an astronomy graduate student at Yale University) its prestigious G. Bruce Blair Award, the Nobel Prize of amateur astronomy.

By 1974, Dunham's mailing list was so huge that the costs of computing predictions, photocopying instructions, and paying for postage exceeded the budget of



JUPITER AND ITS MOONS were occulted by the Moon in the early morning hours of September 15, 1990. The giant planet and its four large satellites vanished behind the sunlit crescent and reappeared (shown here) from behind the dark limb. Lunar occultations of bright planets are easy to see with a small telescope or even binoculars. JACQUES GUERTIN AND RICK BALDRIDGE

DUNHAM'S SCOPE IS READY. Attached to his 5-inch Celestron Schmidt-Cassegrain telescope is a SuperCircuits 35C video camera and a focal reducer. The focal reducer was a bad idea because it degraded the image significantly, Dunham admitted. JOAN BIXBY DUNHAM

DUNHAM and four friends drove from Washington, D.C., to Seneca, Kansas, to observe the grazing occultation of Saturn by the Moon on November 13, 1967. Dunham is second from the right. ROBERT L. SANDY

either his personal finances or what he felt he could beg from any institution with which he was affiliated. So after years of resisting a formal structure, he was compelled to start a quarterly, *Occultation Newsletter*, for a small annual subscription fee. The next year, he founded the International Occultation Timing Association (IOTA), which thrives today.

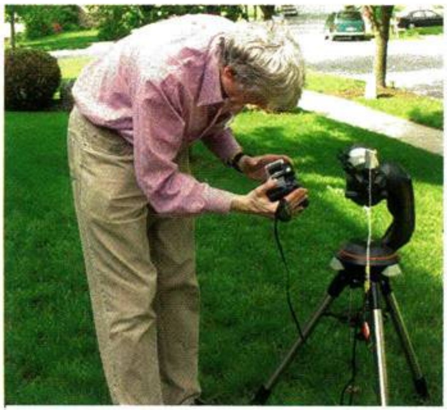
By 1975, grazing occultations had become a staple of amateur observing. With unprecedented accuracy still unsurpassed today (even by the lunar orbiting spacecraft Clementine), grazes helped refine maps of the Moon's polar regions. IOTA's current database includes the results of between three and four thousand grazes observed over the last four decades.

Pursuing shadows of asteroids

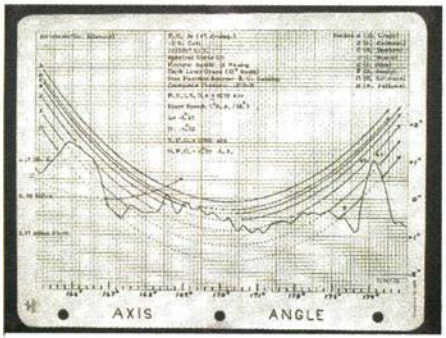
Around the time Dunham founded IOTA, he became intrigued by an even more challenging type of occultation: a star eclipsed by a distant asteroid. The idea wasn't new. Back in the 1950s, Gordon Taylor at the Royal Greenwich Observatory had started predicting occultations of stars by the first four asteroids discovered (1 Ceres, 2 Pallas, 3 Juno, and 4 Vesta) hoping to learn more about the minor planets' exact sizes and shapes. And in 1958 and 1961, observers in Sweden and India successfully watched stars blink and disappear behind Vesta and Pallas.

Compared to grazing lunar occultations, both predicting and observing asteroid total occultations are dicey. First, unlike the Moon, even the largest asteroids are relatively small and more distant than the planet Mars, so none ever shines brighter than 5th magnitude. Thousands of others are even smaller and dimmer; most are only a few tens of miles across and fainter than 13th magnitude. Worse, their great distance means that a small uncertainty in their position in the sky translates into a significant uncertainty in predicting their orbits, and thus predicting the paths their star-cast shadows would sweep across Earth.

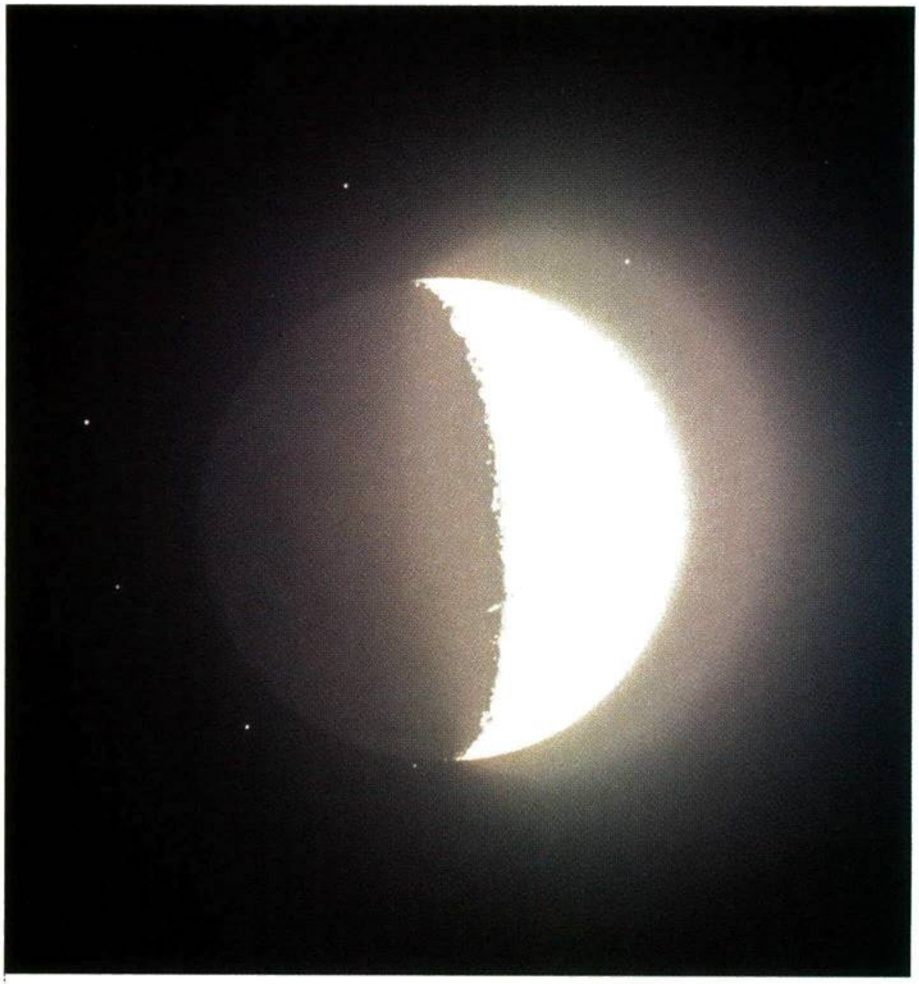
Dunham, however, has always relished a challenge. His chance came in March 1977, when he and Gordon Taylor predicted that observers in the southern United States could see 120-mile-diameter 6 Hebe occult the 3.6-magnitude star Gamma Ceti. From Mexico, through Texas and Florida, Dunham organized observers to time the event. "Right after the event, I first heard from Paul Maley, a veteran occultation and eclipse observer watching from Victoria, Texas, who reported seeing a half-second occultation through his 5-inch refractor," Dunham recalled. But when, an hour later, he heard that three separate observers near Mexico City timed longer occultations, Dunham realized the two sets of observations could not be the same. "Our claim is that we made the first



DUNHAM USES A VARIETY of equipment. Here, he adjusts a SuperCircuits PC 23C low-light level black-and-white video camera prior to attaching it to a 4-inch Celestron go-to telescope. The video is recorded onto a Sony camcorder used as a recorder. JOAN BIXBY DUNHAM



GRAZING OCCULTATION observations help determine the Moon's profile. This profile was made after the grazing occultation of 7.2-magnitude ZC 36 in Cetus on February 13, 1967, near Harrisonville, Missouri. ROBERT L. SANDY



THE MOON IN THE PLEIADES (M45) was photographed on August 6, 1969, at 4:39 A.M. CST immediately after a grazing occultation of the 4th-magnitude star Taygeta (the bright star to the bottom left of the Moon). This photograph is a 6-second exposure taken through a 6-inch f/7.5 Newtonian reflector at prime focus with Ektachrome 160 slide film. ROBERT L. SANDY

discovery of an asteroid satellite!," Dunham exclaimed, "although, at the time, few would believe us." Only after 1993, when close-up images taken by the Galileo spacecraft revealed that the 36 by 14-mile asteroid 253 Ida was accompanied by a 1-mile-diameter companion (later named Dactyl) was it acknowledged that some asteroids indeed are binary.

Dunham's greatest demonstration of his power to mobilize amateurs for asteroid occultations was his enormous push to observe Pallas obscure 4.8-magnitude 1 Vulpeculae on May 29, 1983. Dunham and Maley together fielded more than 240 expeditions totaling more than 400 observers across mainland Mexico, Baja California, Arizona, Texas, Louisiana, and Florida, with 131 expeditions obtaining timings. Clouds obscured the southern portion of the path, and some observers were outside the actual path. Not only did the combined data yield the most accurate size and shape for Pallas, but they also revealed rough variations in the asteroid's topography seen in profile.

The edge of the unknown

What's Dunham's next frontier? Although he's given some thought to occultations by outer solar system objects such as Pluto and smaller Kuiper Belt objects beyond the orbit of Neptune, "they're out of reach for most amateurs, as they usually involve stars fainter than 14th magnitude," he commented. Also, "they're harder to predict with uncertainties of five to twenty times the width of the actual shadow."

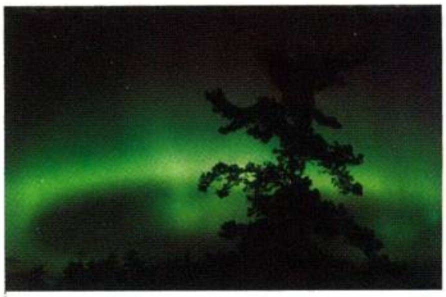
In the meantime, he's encouraging IOTA members to observe total eclipses of the Sun from as close as possible to the northern or southern edge of the path of totality instead of close to the center line (where most amateurs head for the longest duration of totality). "You still see totality," he assured, "but you prolong the dramatic spectacle of Bailey's beads and the diamond-ring effect, and you can watch the beads migrate around the edge of the Moon's black disk." The value of such risk-taking? To determine the exact size of the Sun's diameter and thereby test solar theories whose results depend on tiny changes in the solar diameter over time.

How does Dunham feel about having been a pioneer for four decades, especially as an unpaid amateur astronomer? Never having sought the spotlight, he seems almost embarrassed by such a question. "I'm glad for the opportunities I've had to encourage people to get out and observe events they might not realize are happening," he said thoughtfully. "It takes persistence to get successes. It's not easy. But it's very rewarding." ▣

To learn more about all types of occultations, visit www.astronomy.com/toc

Creating beautiful images of the northern lights is easier than you think. /// TEXT AND IMAGES BY CORY LOEWEN

Capturing aurorae

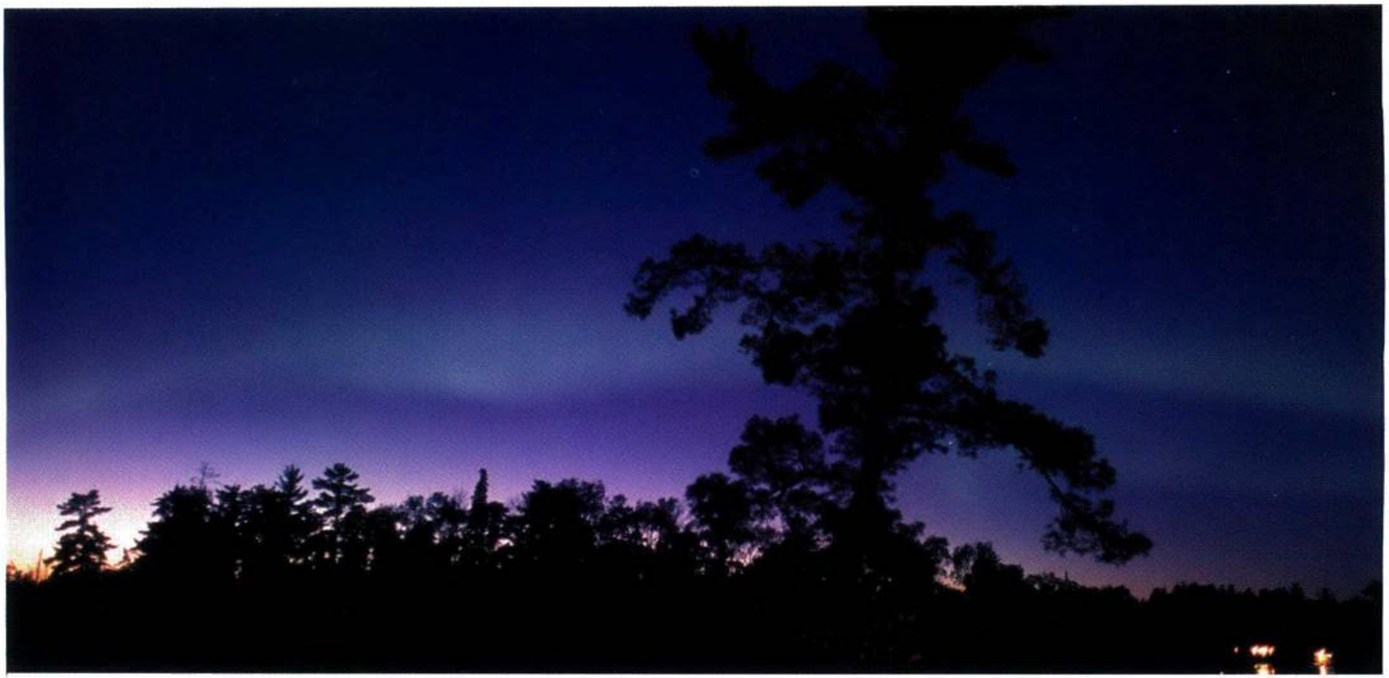


MY FIRST SUCCESSFUL ROLL of aurora images produced this shot. I had taken my first aurora picture ever about four months earlier. The white pine made for a perfect foreground subject. I took this picture from the deck of our cabin. (Pentax K-1000 camera, 28mm lens at f/2.8, 25-second exposure on Kodak Elite Chrome 100 film push-processed to ISO 400, September 24, 2000, at 11:30 P.M. EDT from Lake of the Woods, Ontario, Canada)

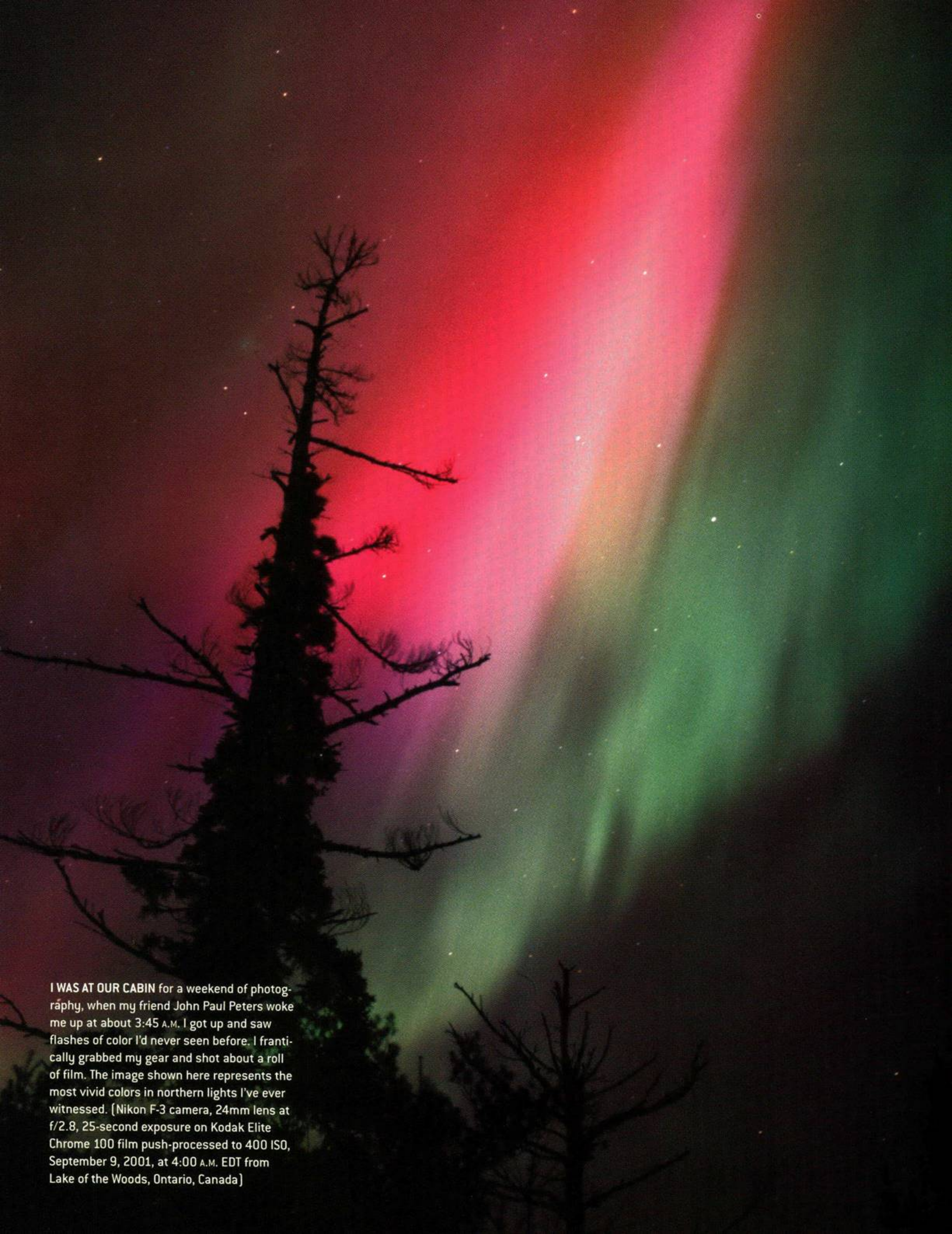
It was a bone-chilling February night when my wife Steph and I headed back to our home in Steinbach, Manitoba, Canada. Leaving the bright glow of Winnipeg behind, the night sky appeared before us. Along with a crystal-clear view of the stars, we noticed the faint green glow of the *aurora borealis* to the north. As crimson hues slowly joined the green, dancing lights flooded the sky.

Not content to view this from inside the car, we pulled off the TransCanada highway. Armed with my new Pentax K-1000 and some Kodak 400 print film, I decided to make my first attempt at capturing this natural phenomenon on film. I laid my camera on our car roof, aimed north, set the camera to B (*Bulb*, used for long exposures) mode, and held my finger on the shutter release button for what I counted to be 30 seconds.

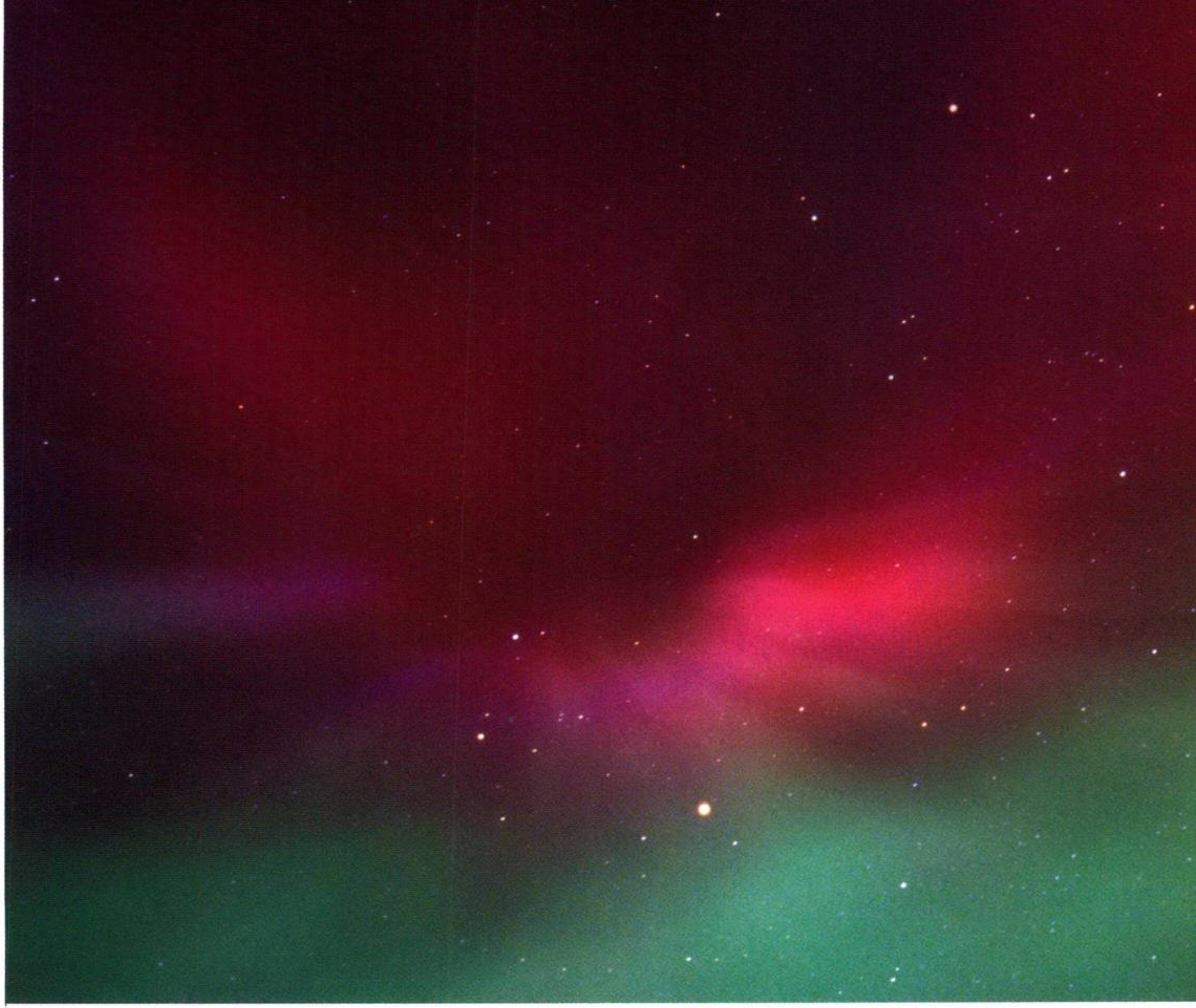
After the film was processed, I was amazed to find an image of the incredible aurora, along with my car roof, some blurry house lights, a crooked horizon, and telephone wires. Thus began my labor of love devoted to creating better and more beautiful photographs of aurorae.



I HAD ALWAYS ADMIRED other photographers' abilities to capture northern lights with a bit of twilight. I finally got my chance one day when the conditions were right, and I was able to record these beautiful blues and oranges combined with the green of the northern lights. The slow film speed really helped to saturate the colors more than they would have been if I had used a faster film. (Nikon F-3 camera, 24mm lens at f/2.8, 25-second exposure on Fuji Provia 100F film, April 19, 2002, at 12:08 A.M. EDT from Lake of the Woods, Ontario, Canada)



I WAS AT OUR CABIN for a weekend of photography, when my friend John Paul Peters woke me up at about 3:45 A.M. I got up and saw flashes of color I'd never seen before. I frantically grabbed my gear and shot about a roll of film. The image shown here represents the most vivid colors in northern lights I've ever witnessed. (Nikon F-3 camera, 24mm lens at f/2.8, 25-second exposure on Kodak Elite Chrome 100 film push-processed to 400 ISO, September 9, 2001, at 4:00 A.M. EDT from Lake of the Woods, Ontario, Canada)



MY CAMERA WAS POINTED STRAIGHT UP as colors were whirling all around me. All the colors seemed to be pouring out of a small point in the sky. With my 24mm lens, 25 seconds is about the limit before stars will appear as blurs across the film. (Nikon F-3 camera, 24mm lens at f/2.8, 25-second exposure on Kodak Elite Chrome 100 film push-processed to ISO 400, October 22, 2001, at 11:55 P.M. EDT from south of Steinbach, Manitoba, Canada)

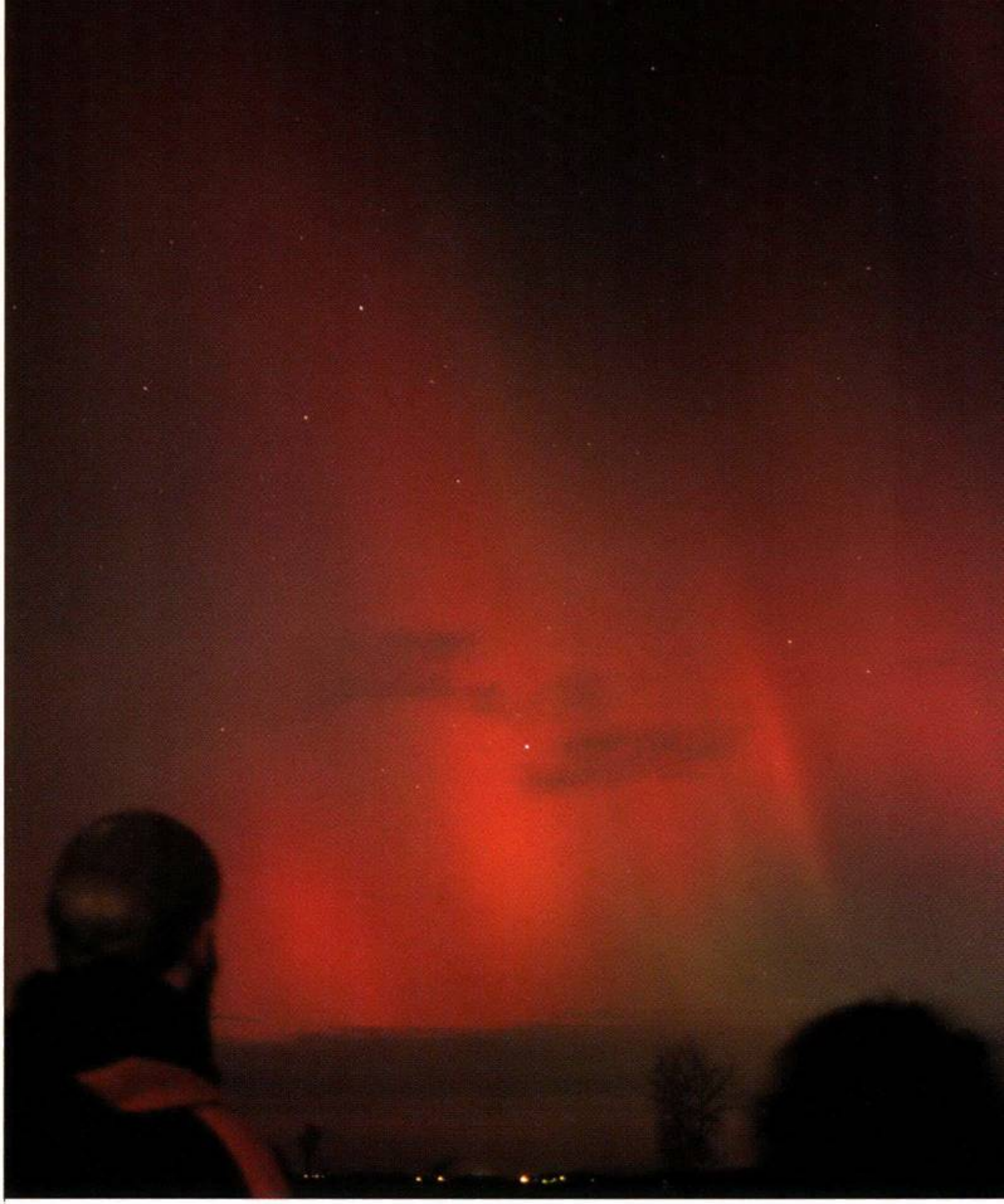
Tools and techniques

Some basic equipment is needed to create photos of the northern lights. First, either borrow or purchase a tripod. The number one camera-related investment I made was a good-quality tripod. Next is the camera body. Pretty much any manual single lens reflex camera with a B or T setting on it will do. This feature allows the camera shutter to remain open. You can hold your finger on the camera's button for the necessary time, but it's best to avoid touching the camera during an exposure to minimize vibrations that will blur the picture. For this purpose, a cable release is a valuable accessory. Please note that electronic cameras place a high load on the battery to keep their shutters open for long periods. Take an extra battery, just in case.

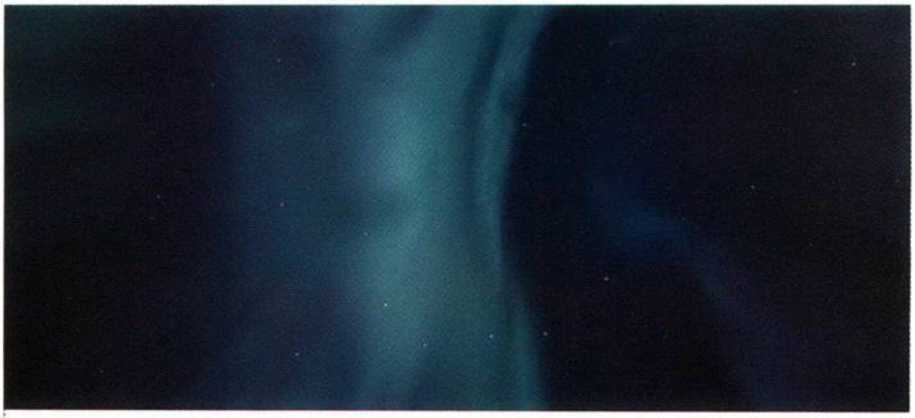
The exposure time needed to record auroral detail depends on the speed of the lens, the intensity and type of aurora, and film speed. A lens that is f/2.8 or faster is necessary to capture intense color. I prefer wide-angle lenses to telephoto lenses — after all, we're photographing large areas of the sky. If your budget permits, invest in a quality lens somewhere in the range of 17mm to 35mm. If money is no object, a 17mm to 35mm f/2.8 zoom lens is ideal. With wide-angle lenses, longer exposures that include stars are possible because the motion of stars is not as apparent as it is with longer focal-length lenses.

Selection of film is not as critical because many types of film (print or slide) will allow you to shoot the northern lights successfully. I've used films as different as Fuji Provia 100F slide film and Fuji Super 1600HG print film with equally great results. My favorite type of film is Kodak Elite Chrome 100 push-processed to 400 ISO. "Pushing" this film not only increases its speed to ISO 400 but also boosts the contrast, which helps show off the night sky. With Elite Chrome, pushing also seems to increase the film's red sensitivity, which is helpful for recording the often-faint red hue of the northern lights. If you use faster film speeds, you can get away with shorter exposure times, which will freeze the ever-changing appearance of the aurora better. Faster films, however, show

Cory Loewen *is an amateur astronomer and nature photographer who lives in Steinbach, Manitoba, Canada.*



I WAS IN OUR APARTMENT when a friend called and said "Cory, you need to go outside now. The sky is bleeding." I ran outside and, sure enough, the sky was covered in a beautiful crimson red. As I made this image, my wife Stephanie and friend Wren Derks were in the foreground enjoying the scene. (Nikon F-3 camera, 24mm lens at f/2.8, 25-second exposure on Fuji Provia 100F film push-processed to ISO 320, November 5, 2002, at 10:30 P.M. EST from Steinbach, Manitoba, Canada)



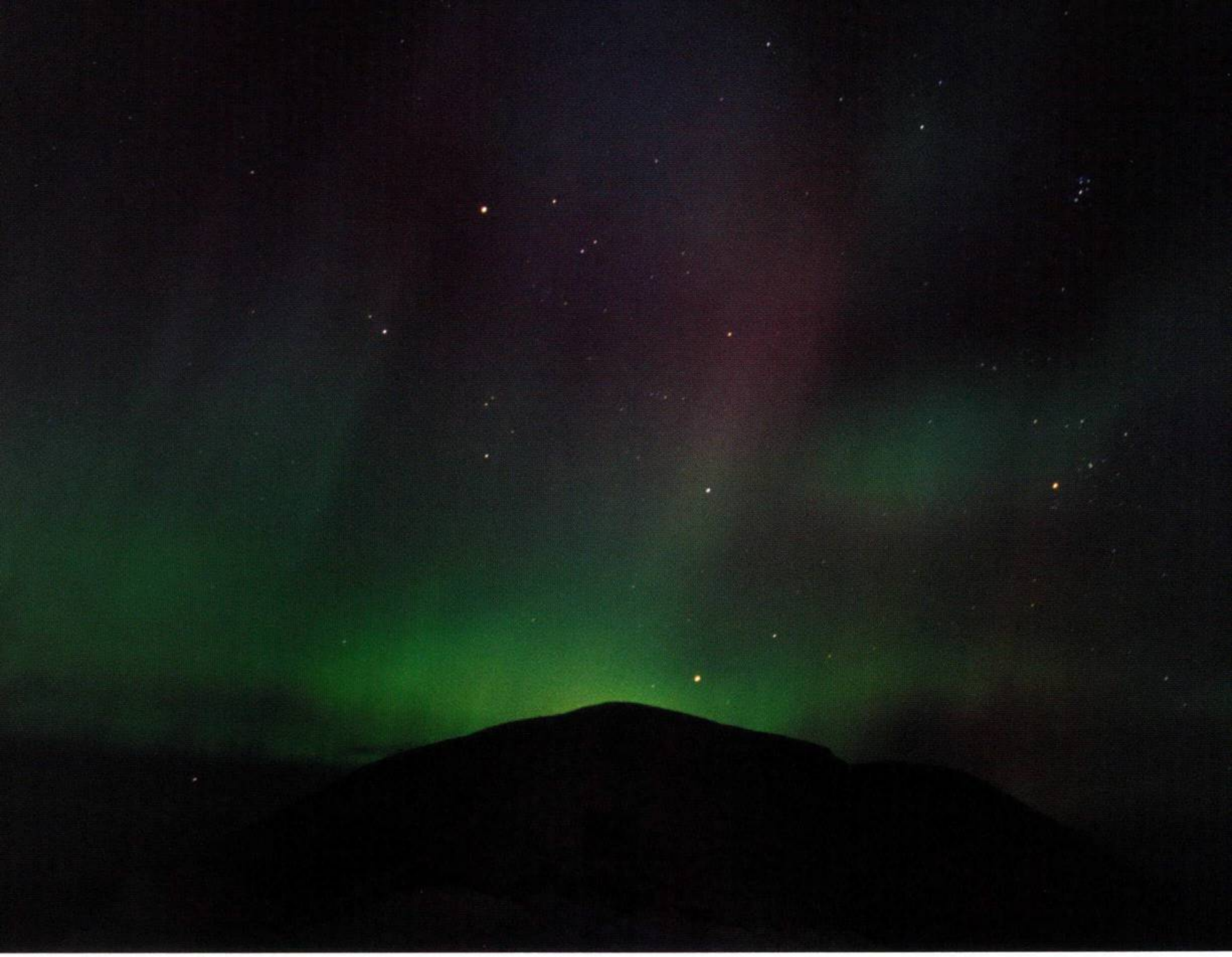
AT THE ZENITH, the colors seemed to pour out into the sky, so that's where I centered the field of view of my camera. I saw a fair amount of blue in this aurora, a color I had never seen before. (Nikon F-3 camera, 24mm lens at f/2.8, 25-second exposure on Kodak Elite Chrome 100 film push-processed to ISO 400, April 19, 2002, at 12:08 A.M. EDT from Lake of the Woods, Ontario, Canada)

more grain in the final image, especially when enlarged to 8x10 or larger prints.

A large number of tables and theories exists to help you calculate how long your exposures should be. No matter how closely you follow any advice, you may not achieve the results you desire. So feel free to try new ideas and techniques. I generally find exposure times between twenty and forty seconds work well for ISO 400 film. If an aurora is pulsing or moving around a lot, you may need a shorter exposure time to avoid capturing a blur of color. If an aurora is moving slowly, you can attempt a longer exposure time, which may reveal detailed shapes and curves. Think of these tips as guidelines, not rules, and don't be afraid to experiment.

Composing an image

One thing we astrophotographers often lack in comparison to other photographers



A LOCAL GRAVEL QUARRY just east of Steinbach provided the setting for this picture. Because I don't live near mountains, I figured I'd improvise and try to capture the same feeling with piles of gravel, which I lit up with a few bursts of my flash. The temperature was about –30° C. This, combined with a driving wind, pushed my fingers to the limit. (Nikon F-3 camera, 24mm lens at f/2.8, 25-second exposure on Kodak Ektachrome E100VS film push-processed to ISO 400, November 2, 2002, at 1:00 A.M. EST from south of Steinbach, Manitoba, Canada)

is an eye for composition. Our tendency is to aim the camera at the northern lights and hope for something interesting. Typically, when you look through the viewfinder, the northern lights and stars disappear. In order to compose more pleasing night scenics, you should look through the viewfinder until your eye adapts to the dark. Then aim your camera at an area of the sky with bright stars, focus, and compose your picture. Tilt the camera up and down to find where the horizon, trees, and stars are located. Doing this will allow you to easily gauge if the horizon is straight. Include a proportional amount of horizon in your shot — too much horizon and the lower half of your picture will be black. Too little, and your picture will look like the camera was about to fall off the tripod.

Unless you specifically want these objects in your picture, avoid including urban distractions such as houses, telephone wires, cars, highways, and city glow. Including foreground objects such as trees, hills, mountains, lakes, and fences adds drama. Try lighting these objects with a flash or a flashlight while the shutter on your camera is open. Experiment with this technique because certain amounts of light are more pleasing than others. Use aurorae as leading lines to foreground objects. Don't be afraid to make foreground objects appear big in your pictures. A frame-filling tree is a lot more dramatic than a faint tree line in the distance.

One way to know when aurorae will be on display is to watch web sites that post when there has been a solar flare aimed toward Earth. *Spaceweather.com* presents a very informative web site that can send you e-mail alerts with auroral predictions. However, northern lights don't always happen according to prediction. Step outside and check the sky whenever possible. And be sure to always have enough film. I now carry a camera, tripod, and film everywhere I go. You never know when you'll see the next incredible show of pulsating reds, greens, purples, and yellows in the night sky. Good luck!

To learn more about CCD imaging, visit www.astronomy.com/toc

THE OLD TRACTOR at my friend Anthony Plett's house and the snow in the foreground were lit by moonlight. I was quite surprised that I could use a 100 speed film to get such good results even without pushing the film. (Nikon F-3 camera, 24mm lens at f/2.8, 25-second exposure on Fuji Provia 100F film, April 14, 2002, at 11:00 P.M. EDT from Blumenort, Manitoba, Canada)

TELESCOPE REVIEW

With good optical quality and lots of included accessories, these two scopes are ones to watch. /// BY PHIL HARRINGTON

TAL's 150K and 200K

Among most city-bound amateur astronomers, the idea of lugging a long refractor or large Newtonian reflector great distances to dark skies is far from appealing. Instead, most opt for the more compact design of either a Schmidt-Cassegrain or Maksutov-Cassegrain. These designs, however, have drawbacks such as field curvature. In addition, dew condensing on the front corrector lens can bring an observing session to an early end.

In 1974, Yuri Klevtsov, an optical engineer from Koltsovo, Russia, addressed these issues with a new design. Klevtsov's design uses a fast focal ratio and a spherical primary mirror like Schmidt- or Maksutov-based designs, but it does not use a large corrector lens at the front of the tube. Instead, Klevtsov's design has an open tube that uses a two-element "Mangin secondary."

Invented in 1876, a Mangin secondary is a combination mirror and lens assembly used to correct spherical aberration. It is a two-lens assembly with the rear surface of the second lens (that is, the lens surface closest to the front of the tube) aluminized like a mirror. Light passes through the two elements of the Mangin secondary, reflects off the aluminized back of the second element, and travels back through the two lenses through a hole in the primary mirror to the eyepiece.

One immediate benefit of the Klevtsov-Cassegrain design is a greater resistance to dewing because there's no front-end corrector lens. Another benefit of the open tube is that the optics cool faster.

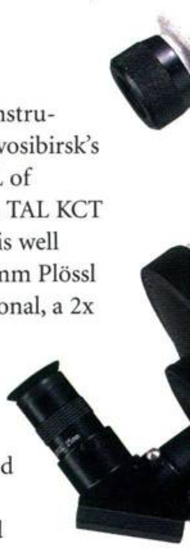
THE 8X50 FINDER SCOPE of the TAL 200K is a noteworthy accessory. Sharpen the field of view by turning a nicely machined helical focuser. *ASTRONOMY*: WILLIAM ZUBACK

Despite these pluses, Klevtsov's design has seen only limited use in the amateur market. In fact, only Vixen Optical Industries in Japan and the Novosibirsk Instrument-Making Plant in Russia manufacture amateur-size Klevtsov-Cassegrain telescopes, or KCTs. The name Novosibirsk may not be familiar, but you might know their line of TAL Newtonian reflectors. Heavy-duty German equatorial mounts and robust metal tube assemblies characterize these instruments.

Phil Harrington *is the author of the new observing guidebook* Star Watch, *which is published by John Wiley & Sons.*

Following the same manufacturing philosophy, the TAL family of telescopes includes two KCT models: a 6-inch f/10.3 150K and an 8-inch f/10 200K. Like the TAL Newtonians, the TAL KCTs are solidly made, all-metal instruments.

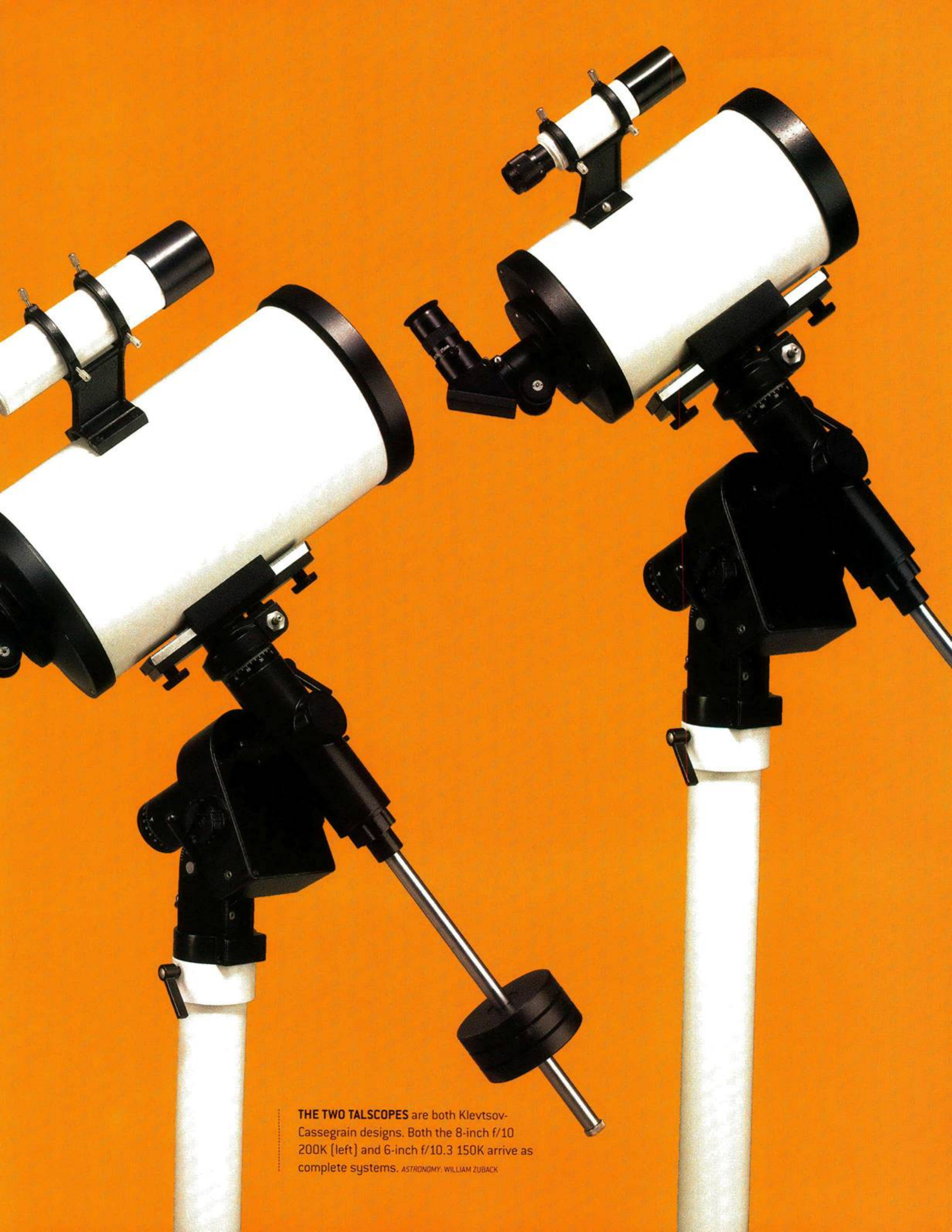
A complete system



For this review, I received both instruments in one shipment from Novosibirsk's North American distributor, TAL of Kingston, Ontario, Canada. Each TAL KCT features a glossy white tube that is well accessorized with 10mm and 25mm Plössl eyepieces, a 1¼" mirror star diagonal, a 2x "shorty" Barlow lens, a straight-through finder scope, a camera adapter, a set of color filters, Sun and Moon filters, and a dovetailed plate for attaching the tube assembly to the pier-mounted German equatorial mount. In short, you get everything you need to start observing right out of the box.

I must issue one warning up front. The Sun filter that comes with these instruments is the kind that screws into a telescope eyepiece. ***Such filters are extremely dangerous and should never be used under any circumstances.*** "Eyepiece" solar filters have been known to shatter within a few seconds of exposure to the focused fury of the Sun's light and heat, instantly blasting blinding light into an observer's eye. Most manufacturers — even those that sell low-end telescopes — have long since discontinued making these ill-conceived filters. So throw away the Sun filter as soon as you unpack the telescope.

The TALscopes arrived safely, strapped and shrink-wrapped to a wooden pallet. The 150K was packed in a heavy, fitted wooden case with brackets that secured the telescope's tube assembly, equatorial mount, finder scope, and other accessories. The 200K was sent as an optical tube assembly (OTA) only because both the



THE TWO TALSCOPES are both Klevtsov-Cassegrain designs. Both the 8-inch f/10 200K [left] and 6-inch f/10.3 150K arrive as complete systems. *ASTRONOMY*: WILLIAM ZUBACK

THE HAND CONTROLLER for the 150K and 200K TALscopes allows three different tracking rates and slow and fast slewing motions. *ASTRONOMY*: WILLIAM ZUBACK

150K and the 200K scopes can be used interchangeably on the same mount.

Specifications

The TAL KCTs are hefty telescopes for their sizes. The 150K measures only 14.5 inches in length (including the focuser) but weighs 16 pounds, while the larger 200K measures 19 inches long and weighs 19.5 pounds.

The German equatorial mount and 40.5-inch-long steel pier are no lightweights either, weighing 47 pounds when assembled. A shorter, 31.5-inch-long pier cuts off 4.5 pounds, but it's best suited for viewing through the telescope from a seated position. With everything assembled, including the taller pier, the TALscope 150K weighs 63 pounds, while the 200K tips the scale at 66.5 pounds.

Both TAL KCTs use rack-and-pinion focusers rather than moving the primary mirror in and out, as Schmidt-Cassegrain and most Maksutov telescopes do. Neither focuser worked smoothly because each came coated with thick, sticky grease on its drawtube. Once I removed the grease with a solvent and then coated the drawtubes lightly with a dry silicone spray, the focusers worked much better.

Incidentally, the TAL 1¼" focuser is designed to accept only Novosibirsk's unusual star diagonal. Because the diagonal's barrel tapers slightly, users can loosen the thumbscrews that hold the diagonal in place to rotate it without dropping it out of the focuser. While it's a good idea, this also means you cannot substitute another brand's diagonal unless you first install longer thumbscrews.

Both TAL KCTs come with straight-through finder scopes. The 150K's 6x30 finder scope is acceptable but not terribly noteworthy. The 200K's 8x50 finder, however, impressed me as one of the finest available today, both optically and mechanically. Rather than focusing by turning the objective lens housing, the 8x50 finder's eyepiece is set into a nicely machined helical focuser.

I have two small complaints about the finders, however. First, the 6x30's crosshairs are too thick, while the 8x50's are too thin, completely disappearing from view on dark nights. Second, both finders come with plastic, slip-on dew caps that seem to belie the finders' quality. But even with these issues, I still give the 8x50 finder high marks. This finder scope also may be purchased separately for $89, a price that includes a dovetailed mounting plate.

Mount and drive

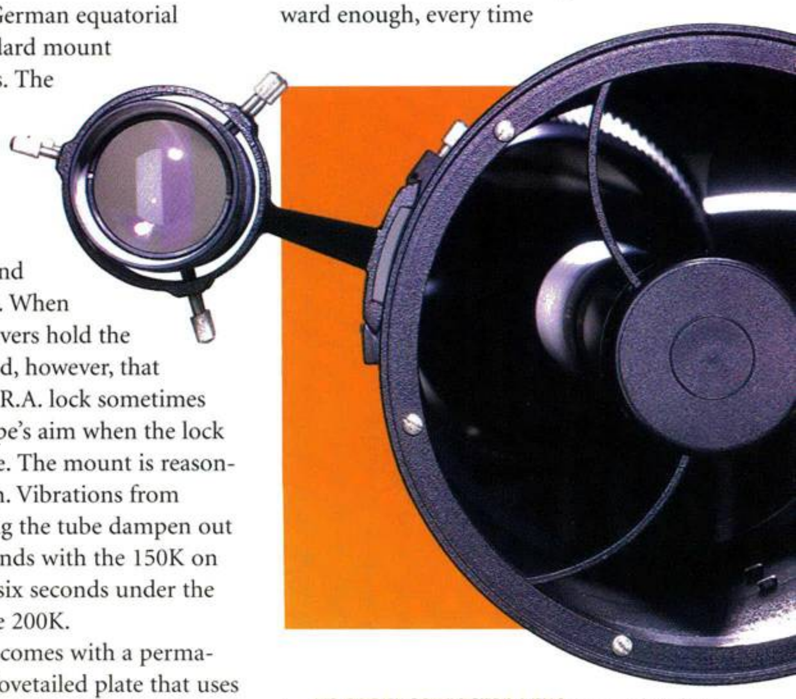
TAL's GEM200K German equatorial mount is the standard mount for both telescopes. The GEM200K uses preloaded ball bearings in both axes for smooth motions in right ascension (R.A.) and declination (Dec.). When secured, locking levers hold the axes tightly. I found, however, that the spring-loaded R.A. lock sometimes shifted the telescope's aim when the lock clamped into place. The mount is reasonably sturdy though. Vibrations from focusing or tapping the tube dampen out in about four seconds with the 150K on top, and in about six seconds under the extra weight of the 200K.

Each telescope comes with a permanently mounted dovetailed plate that uses captured hardware (bolts that remain attached to the plate at all times) and has a pair of tapered guide pins for aligning the telescope to the mount. I really came to appreciate these little niceties whenever I attached the tube to the mount in the dark — when it can be nearly impossible to align the two pieces. The dovetailed plate also can slide forward and backward to make balancing the scope easier.

The mount comes with a clock drive that uses a 180-tooth worm gear on the R.A. axis. The drive can be sped up or slowed down using the included hand controller. Although the drive uses a 12-volt DC motor, the only power is via a small transformer that plugs into a 110-volt AC outlet. At present, Novosibirsk does not offer a connector for an automobile accessory plug, although according to the company, one will be available soon. A polar alignment scope with reference grids for aligning with both the north and south celestial poles also is included. The drive, however, is set up for tracking only from the Northern Hemisphere.

The hand controller lets you change between solar, lunar, and sidereal tracking rates. Each axis also has a manual motion control. No provision has been made for a declination motor. Although the clock drive tracked the stars accurately, operating the hand controller was not intuitive.

Setting the tracking speed is simple. Just press one of three rate buttons on the controller. While that's straightforward enough, every time

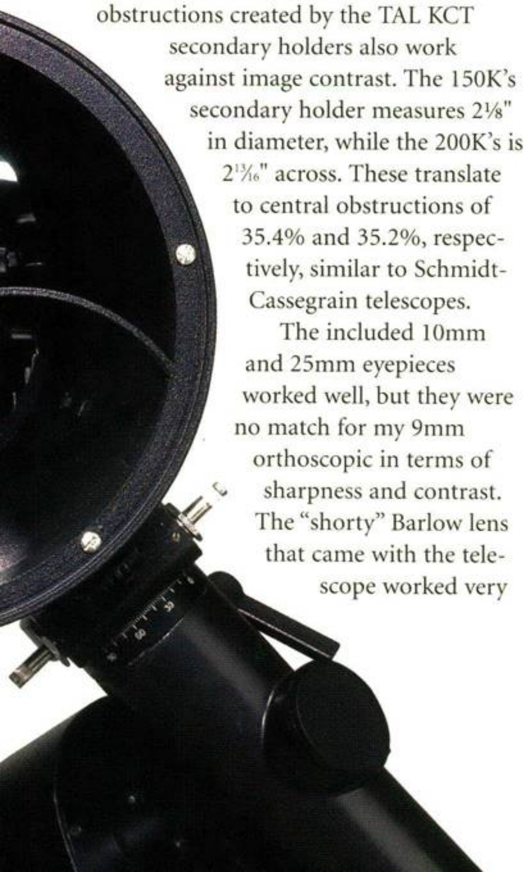


NO FRONT CORRECTOR LENS means that dew has a more difficult time forming on the optical surfaces of the 150K and 200K TALscopes. *ASTRONOMY*: WILLIAM ZUBACK either the slow or fast slew button is pressed, the drive rate is canceled. This means the user has to turn the drive back on by pressing one of the three rate buttons again. This odd arrangement is not well detailed in the instructions.

The GEM200K mount came perched atop a heavy, well-designed steel pedestal. Three aluminum legs attach to the pier with captured hardware and have feet that are cushioned with plastic pads. The plastic pads work to a limited degree, but separate vibration pads are a better solution. The TAL KCTs also may be purchased with wooden tripods, if desired.

Star testing

The results of my star-tests were that neither scope showed any astigmatism, but each suffered from a small amount of spherical aberration. Although the results are difficult to compare precisely against those in Richard Suiter's book *Star Testing Astronomical Telescopes*, the optics in the 150K were approximately one-quarter wave. Those in the 200K were slightly less precise at about one-third wave. Quarter wave optics, typically referred to as "diffraction limited" by manufacturers, is the minimum level of precision needed to achieve proper focus at reasonably high magnifications (above 200x).



The large diameters of the central obstructions created by the TAL KCT secondary holders also work against image contrast. The 150K's secondary holder measures 2⅛" in diameter, while the 200K's is $2\frac{13}{16}$" across. These translate to central obstructions of 35.4% and 35.2%, respectively, similar to Schmidt-Cassegrain telescopes.

The included 10mm and 25mm eyepieces worked well, but they were no match for my 9mm orthoscopic in terms of sharpness and contrast. The "shorty" Barlow lens that came with the telescope worked very well, and it's definitely a keeper. Like the 8x50 finder, the Barlow also is available for purchase separately ($45).

Under the stars

As a result of the above factors, my views of Mars through the TAL KCTs last autumn didn't show the level of detail I saw through an 8-inch Newtonian (with a smaller central obstruction) set up nearby. Mars, of course, is an unforgiving target, even under the best conditions. Both TAL models did better with Jupiter and Saturn. The Ringed Planet looked especially nice through the 150K when viewed with my 9mm orthoscopic eyepiece.

The TAL KCTs worked fine when it came to resolving star clusters. Both telescopes nicely resolved the great globular cluster M13 in Hercules. The 150K proved the sharper of the pair, but the 200K's images were distinctly brighter. Other showpiece objects, such as the Ring Nebula (M57), the Dumbbell Nebula (M27), and globular clusters M22, M15, and M2, looked quite nice through both telescopes. The supplied eyepieces worked but did not let either instrument live up to its potential. When I used premium eyepieces from Tele Vue, Vixen, and Pentax, I noted quite a difference in visual performance, although even with these, images did not "snap" into focus.

THE QUALITY WORKMANSHIP is readily apparent in the TAL KCTs. Each optical tube is mated to its mount by a dovetailed plate (lower right). *ASTRONOMY*: WILLIAM ZUBACK

The compact design and well-appointed accessories set the TAL KCTs apart. If you're looking to buy a complete telescope package where all you need to add are star charts and a clear night sky, and if you're willing to overlook a few idiosyncrasies, then the TAL Klevtsovs from Novosibirsk are worthy of consideration. ■

/// TALSCOPE 150K AND 200K SPECIFICATIONS

Scope	Aperture	Focal ratio	Weight (OTA)	Weight (Total)	Mounting	Price
150K	6 inches	f/10.3	16 lbs.	63 lbs.	German equatorial on pier	$1,295 total $1,050 (OTA only)
200K	8 inches	f/10	19.5 lbs.	66.5 lbs.	German equatorial on pier	$1,550 total $1,295 (OTA only)

Equipment

- R.A. clock drive with hand controller
- Manual slow motion controls on both axes
- Setting circles
- Dovetailed plate
- 6x30 finder scope (Note: the 200K comes with an 8x50 finder scope)
- 10mm and 25mm 1¼" Plössl eyepieces
- 1¼" star diagonal
- 1¼" 2x Barlow lens
- Moon filter
- Sun filter (see warning in article)
- Camera adapter for converting to standard T2 camera mount
- Wooden storage crate

Contact information:

Novosibirsk Instrument-Making Plant
(TAL Instruments)
179/2 D. Kovalchuk St.
Novosibirsk, 630049, Russia
[t] 7.3832.260765
[w] www.telescopes.ru

North American distributors:
TAL
599 Norris Court, Kingston,
Ontario, Canada K7P 2R9
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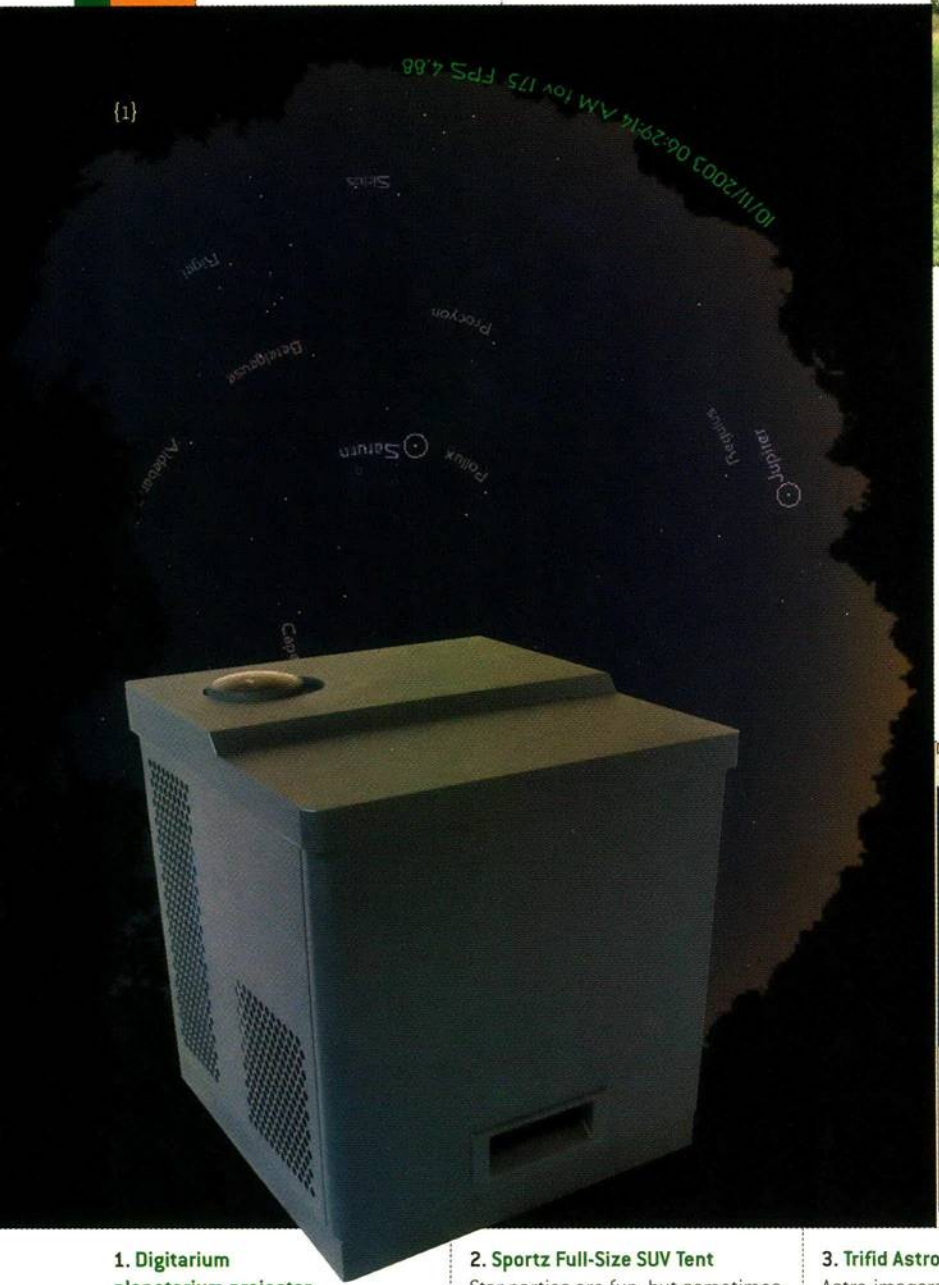

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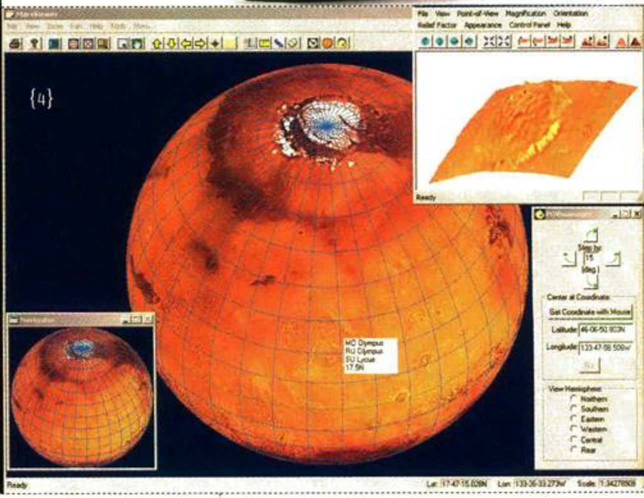

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$13,900; Digitalis Educ. Solutions
P. O. Box 2976
Bremerton, WA 98310
[t] 360.616.8915
[w] www.digitaliseducation.com

2. Sportz Full-Size SUV Tent
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$229.95; Napier Enterprises
2315 Whirlpool Street, Suite 161
Niagara Falls, NY 14305
[t] 800.567.2434
[w] www.sportzbynapier.com

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Astro-imagers now can choose the resolution of their CCD camera. The Trifid Astronomical Camera carries one of four Kodak image sensors ranging in size from ⅓ to 6 megapixels. This camera is just 4½" in diameter and 3" deep. It fits a 2" focuser and operates on 12 volts (adapter included). Accompanying software allows a 6 megapixel image to download in only two seconds.

from $2,285; Yankee Robotics, LLC
16541 Redmond Way, #400
Redmond, WA 98052
[t] 888.367.9265
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4. *Celestial Explorer: Mars*
Most software related to Mars is written with the telescopic observer in mind. *Celestial Explorer: Mars*, however, was designed specifically to help amateur astronomers follow closely the exploration of Mars by NASA spacecraft. The software is packed with NASA's latest digital satellite maps of Mars, the most up-to-date geology data, and futuristic 3-D graphic visualizations.

$35; RITI
274 Main Street, Suite 302
Reading, MA 01867
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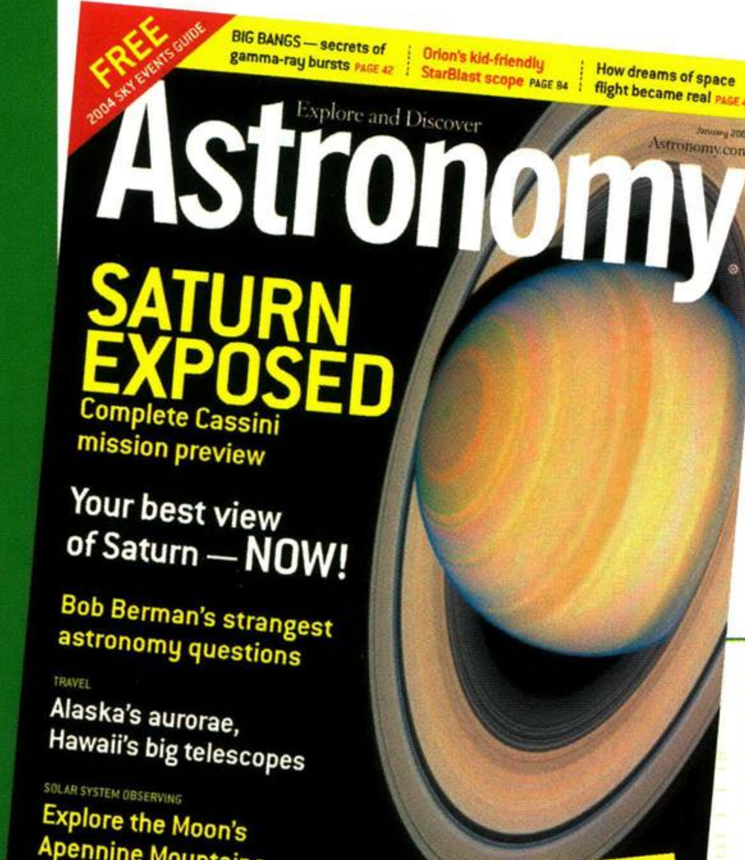
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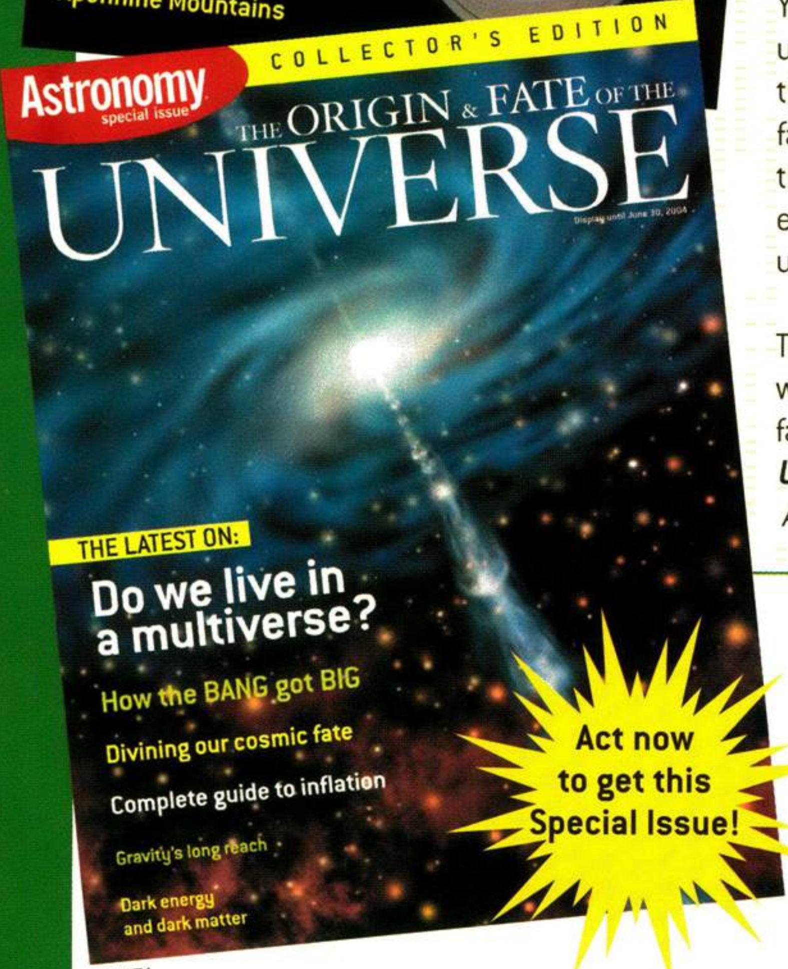
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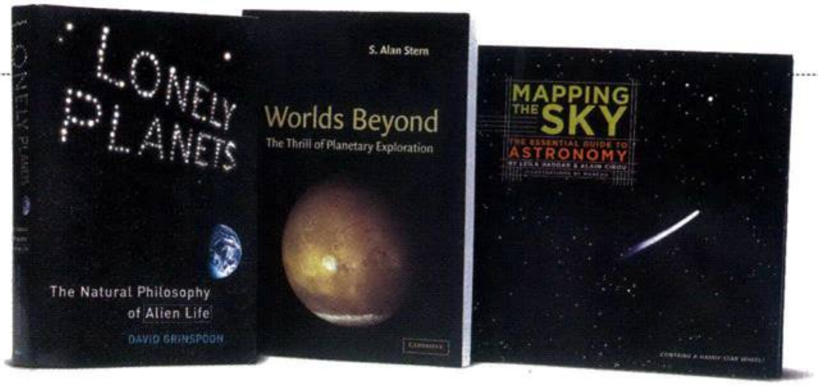

LONELY PLANETS
The Natural Philosophy of Alien Life
DAVID GRINSPOON
S. Alan Stern
Worlds Beyond
The Thrill of Planetary Exploration
MAPPING THE SKY
THE ESSENTIAL GUIDE TO ASTRONOMY

Lonely Planets: The Natural Philosophy of Alien Life

David Grinspoon, 464 pages, HarperCollins, New York, 2003; ISBN 0–0601–8540–6; hardcover, $25.95.

David Grinspoon has succeeded marvelously at producing a comprehensive, enjoyable overview of astrobiology, the epitome of multi-disciplinary research. Emphasizing the most important topics, he maintains a balanced view of the science as a whole. This is no mean feat in a field rife with personal agendas and professional prejudice.

As the title suggests, the book contains a history of the thoughts — some hundreds of years old — about extraterrestrial life. The reader is surprised to find how old many of the supposed modern ideas in astrobiology are — the Fermi Paradox ("Where are they?"), for example, was first expressed about half a century before Fermi stated it.

Grinspoon often diverts the narrative to reminisce about his first contact with an idea, a discovery, or a famous person, and the effect it had on his thinking and interests. Professional scientists may see this as undesirable. However, young people contemplating an astrobiology career will be fascinated — they will sense Grinspoon's delight (and sometimes repulsion) and his realization that he still has much to learn. It will give them a feeling for what it is like to embark on a scientific career. Seeing how normal people become scientists will enlighten and, hopefully, encourage them.

The enigmatic title of the book may suggest, misleadingly, that it rehashes *Rare Earth: Why Complex Life is Uncommon in the Universe*, a recent book by Peter Ward and Donald Brownlee. Indeed, many chapters sound as though they share *Rare Earth*'s pessimism about the cosmic abundance of complex life (but not primitive life). However, Grinspoon is very knowledgeable about the endless complexities and oddities of biology and planets. Everything is here — theories of planetary formation and evolution, the origin of life, the evolution of complex life, and even the evolution of intelligence and technology. The reader slowly reaches a conviction, endorsed in the book's final words, that space is rich in intelligent creatures.

One twist, which may seem very strange and even depressing, is a long section on the possible reality of UFOs. What is *that* subject doing in an otherwise scientifically sound book? Here again, we encounter Grinspoon's experiences. He plunges into this world, troubling to a scientist and rife with anecdote, misperceptions, con men, fraud, hoaxers, and the insane. He emerges (as I did when I made the same investigation) with the conclusion that there's nothing of importance here — except to psychologists, psychiatrists, and district attorneys.

The writing is superb. Although unabashedly technical, it is an easy, if long, read. Grinspoon occasionally uses slang and "street talk," which may trouble older readers. However, much more often one hears echoes of the beautiful prose of the late and much missed Carl Sagan and Stephen J. Gould.

Anyone, even a professional scientist, who wishes to become familiar with contemporary astrobiology should read this book. It's a prime place to become more than casually acquainted with one of the hottest, most interesting fields of science.
— FRANK DRAKE *is chairman emeritus of the SETI Institute in Mountain View, California.*

Worlds Beyond: The Thrill of Planetary Exploration

S. Alan Stern, 161 pages, Cambridge University Press, New York, 2002; ISBN 0-521-52001-0; paperback, $21.

Stories written by explorers reveal the beauty and wonder of the world they seek and the seeking experience. Here, editor Alan Stern gathers essays from ten explorers of vastly differing vistas within our own solar system. The preface promises a view into the science and into the hearts of the scientists. To accomplish both is a challenge, requiring a delicate interweaving of personality and hard data.

Several essays are deliciously revealing of their authors. Stern himself, for example, smoothly integrates his personal story with a discussion of the object of his quest — Pluto. The resulting essay gives the reader an appreciation for the world Stern studies and for his desire to study it. Similarly, Richard Binzel begins his story early in youth and gradually draws us along as he learns about asteroids. One of the delights captured by Binzel is how a career path may twist and turn while steadily propelling forward, sometimes leading us right back where we started but with new awareness gleaned along the way.

Matthew Golombek's essay about exploring Mars projects an honesty, sincerity, and humility that had me chuckling, commiserating, and thoughtfully considering. All young scientists should read it before joining a planetary exploration mission.

The volume is uneven in tone. In some essays, personalities sparkle but the blend with the science is awkward. In both Robin Canup's and Michael Zolensky's essays, momentary flashes of passion led me to seek the paragraphs where their wit and drive shone through. I wished the editor had helped these writers integrate their personal voices more with the science.

In other cases, the glare of the target world swamped the writer's personality; the essays of Steven Strom (Mercury) and Christopher McKay (Titan) suffered in this regard. Harrison Schmitt's chapter was perhaps the most disappointing. As the one real explorer in the book (he walked on the Moon in 1972), Schmidt's perspective is unique, yet his essay contained little personal content.

Overall, the book shares enough stories to be worth the read. By experiencing the diversity of the writers and their favorite worlds, you gain a broader appreciation of our planetary neighborhood.

— **HEIDI HAMMEL** *is a planetary astronomer who works for the Space Science Insititute of Boulder, Colorado.*

Mapping The Sky: The Essential Guide to Astronomy

Leïla Haddad and Alain Cirou, 338 pages, Chronicle Books, San Francisco, 2001; ISBN 2-02-059692-X; softcover, $24.95

This book is a treat for the eye and mind. White text on dark blue pages accompanied by gorgeous illustrations of ancient sky charts, armillary spheres, and engravings from the Renaissance give *Mapping the Sky* the ambience of a gallery exhibit.

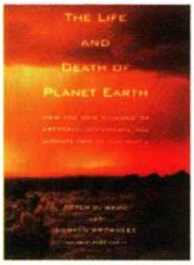
Science writer Leïla Haddad takes the reader through the mysteries of space and time as met by ancient civilizations and the genius of Galileo, Kepler, and Newton. It makes a delightful journey of discovery. The depictions of an Earth-centered universe and fixed sphere of stars engage the eye and provide an introduction to the sky's visual motions. Although Haddad's approach is topical rather than chronological and tends to hop back and forth through time, the distraction is minor.

So it's rather a letdown when the original theme morphs into yet another beginner's guide to astronomy about halfway through. Undeniably, the second half features fabulous photos of equipment and deep-sky objects, and there is plenty of sound advice peppered with interesting factoids. But Alain Cirou's flair for the romance of observing translates poorly into the technical aspects of choosing a scope; and blurry, full-color pictures of the planets impart little information.

The title, too, is unfortunate because it leads you to expect star charts. But all you get are a few constellations traced on fish-eye photos, and one of these mislabels Epsilon Bootis as Arcturus. (In fairness, the original French title makes no reference to sky maps.) The inclusion of a planisphere was a nice touch, but its small size only reinforces the idea that the book is mainly an armchair exercise.

This is indeed a pretty book, but its purpose seems to have gotten lost between the two themes. Nonetheless, if it's read as a colorful and revealing overview of the quest to comprehend the celestial vault, both novice and seasoned skygazers will find hours of entertainment between the glossy covers of this book.

— **GLENN MULLER** *currently chairs the Hamilton (Ontario) Amateur Astronomers.*



The Life and Death of Planet Earth: How the New Science of Astrobiology Charts the Ultimate Fate of Our World

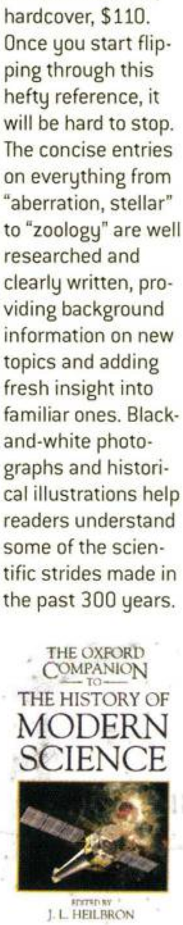
Peter D. Ward and Donald Brownlee, 240 pages, Times Books, New York, 2002; ISBN 0–8050–6781–7; hardcover, $25.

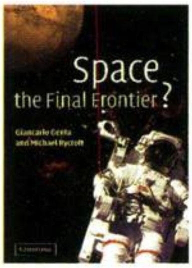
This doomsday scenario by two scientists is so well reasoned and vividly imagined that the pages fly by. Ward and Brownlee fast-forward to Earth's far-distant future. They write: "[T]here will not be one 'end of the world' but many . . . that will make our Earth as bizarre and alien a place in the distant future as it was in its distant past." Buckle up.

The Oxford Companion to the History of Modern Science

Edited by J. L. Heilbron, 960 pages, Oxford University Press, New York, 2003; ISBN 0–1951–1229–6; hardcover, $110.

Once you start flipping through this hefty reference, it will be hard to stop. The concise entries on everything from "aberration, stellar" to "zoology" are well researched and clearly written, providing background information on new topics and adding fresh insight into familiar ones. Black-and-white photographs and historical illustrations help readers understand some of the scientific strides made in the past 300 years.





Space, the Final Frontier?

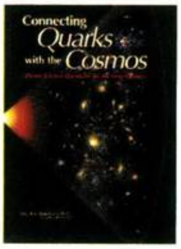
Giancarlo Genta and Michael Rycroft, 401 pages, Cambridge University Press, New York, 2003; ISBN 0–5218–1403–0; hardcover, $29.

Dedicated to "future generations of the human species," this book runs the gamut on all things space related. Aerospace engineer Genta and atmospheric scientist Rycroft discuss the value of space exploration, touching on past and future space missions and spacecraft. They also tackle topics with a "sci-fi" edge, including the use of robots in the solar system, the possibility of drawing energy from the gas giant planets, and the search for extraterrestrial intelligence.

Connecting Quarks with the Cosmos: Eleven Science Questions for the New Century

National Research Council, 222 pages, The National Academies Press, Washington, D.C., 2003; ISBN 0–3090–7406–1; softcover, $39.

How did the universe begin? Are there more space-time dimensions? What is dark energy? Several dozen scientists met over the course of a few years to choose and ponder these and eight other intriguing questions at the intersection between physics and astronomy. The result is a remarkably accessible book that lays out the field's most important questions and the paths toward answering them.



Celebrate Astronomy Day with *Astronomy* Magazine!

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To request your free materials, e-mail Jerry Burstein: jerry@astronomy.com
For a helpful resource about organizing an Astronomy Day event, visit us on the web at www.astronomy.com

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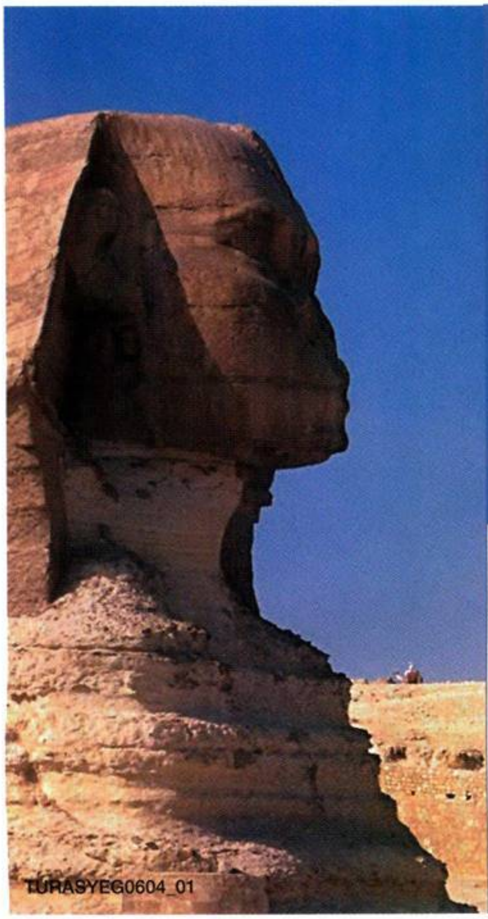

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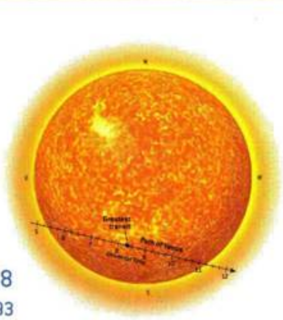

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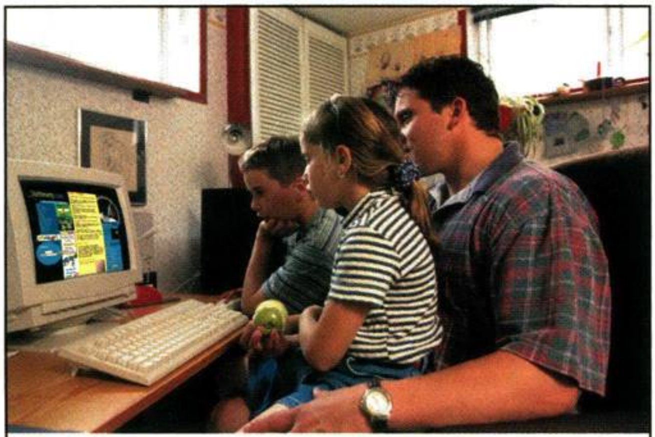

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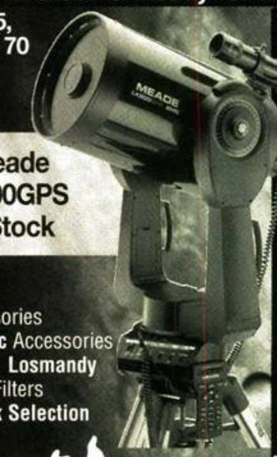

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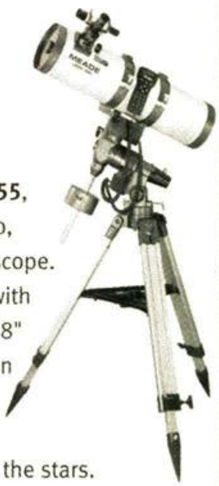

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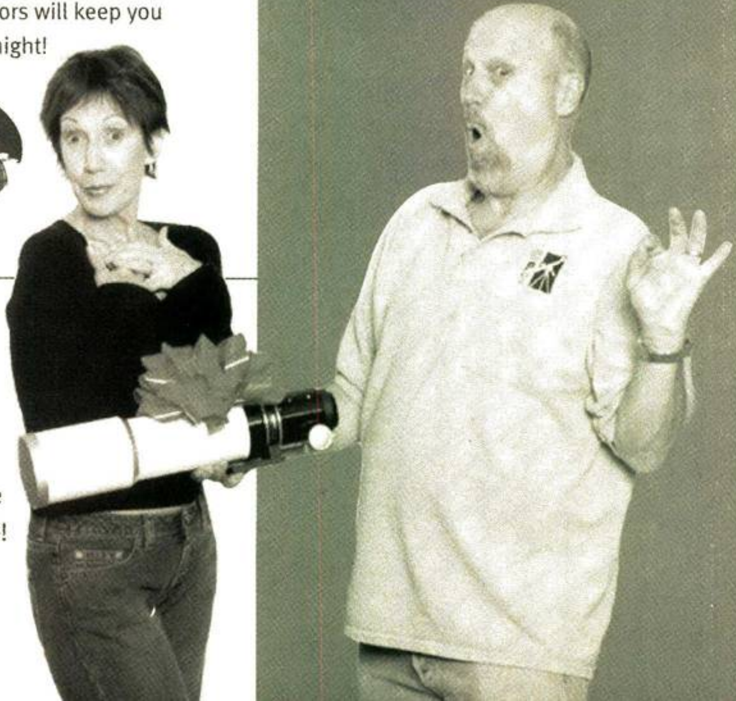

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04.24.04

Astronomy Day is a worldwide campaign that allows astronomical organizations, planetaria, observatories, and other skygazers to share their passion for astronomy with the public. On this day, amateur and professional astronomers participate in events

AS JUPITER reaches opposition and shines at magnitude −2.5, observers will have their best view of this giant planet in early March. NASA/JPL/UNIVERSITY OF ARIZONA

that promote astronomy and answer people's questions concerning the subject.

While most groups observe only Astronomy Day, it is actually part of a weeklong celebration held around the time of the First Quarter Moon between mid-April and mid-May.

To find Astronomy Day events in your area, contact local museums, science centers, parks, observatories, astronomy clubs, or planetaria. For further event listings, visit our on-line calendar at www.astronomy.com/Calendar/Default.asp.

UNTIL 05.09.04

SPACE: A Journey to Our Future

Pacific Science Center, Seattle. This exhibit provides a hands-on, educational experience for all ages. Visitors can handle actual lunar rocks, explore a simulated International Space Station, and take the helm to land a virtual lunar module. For more information, call 206.443.2001; web site, www.spaceevent.com.

03.06.04

Tri-Star 2004

Guilford Technical Community College, Jamestown, North Carolina. Cosponsored by the Cline Observatory and Greensboro Astronomy Club, this event features speakers, prizes, and vendors. For more information, visit technet.gtcc.cc.nc.us/comserv/cline/tristar.htm.

03.17.04–03.21.04

South Pacific Star Party

Wirruna, about three hours northwest of Sydney, Australia. Astronomers of all levels will gather to observe under the dark Australian night sky. The location is a nature lover's paradise, featuring kangaroos, wombats, and a variety of birds. For more information, visit www.asnsw.com/spsp.

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Latest news from the Red Planet: all about Mars Express, Beagle 2, and Mars Exploration Rover Spirit.

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Ever wonder about the myriad cloud belts and other features on Jupiter? If so, this guide to the Giant Planet is just what you need.

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Lots of things can go wrong in the field of astrophotography, from equipment failure to human error. Follow along (and learn by example) as one astrophotographer shares some of his worst — and best — astronomical images.

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Konus scope review
Find out what *Astronomy* likes best about this new Maksutov-Cassegrain telescope system.

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03.19.04–03.21.04

Spring Norfolk Star Party

Kelling Heath, Norfolk, United Kingdom. This site is particularly dry for the region. Observers at this star party will be challenged by a Messier marathon. For more information, e-mail info@starparty.org; web site, www.starparty.org.

03.29.04–04.02.04

Royal Astronomical Society National Astronomy Meeting

The Open University, Milton Keynes, United Kingdom. This meeting will be largely lecture-based, focusing on the science aspect of astronomy. For more information, e-mail the RAS at ras-nam04@open.ac.uk; web site, physics.open.ac.uk/nam.

04.13.04–04.17.04

Titan: From Discovery to Encounter

European Space Research and Technology Center, Noordwijk, Netherlands. Commemorating the 375th anniversary of Christiaan Huygens's birth, this conference will bring together historians and space scientists to examine this important figure in astronomical history. Lecturers also will discuss the Huygens space probe that will crash into Saturn's largest moon, Titan. For more information, visit sci2.esa.int/huygens/conference.

04.14.04–04.17.04

Mid-South Star Gaze

Rainwater Observatory, near French Camp, Mississippi. Designed for anyone interested in learning about astronomy, this gathering will feature lectures and informal day and nighttime observing sessions. For more information, e-mail rainwater@astronomers.org; web site, www.rainwaterobservatory.org/stargaze.

04.23.04–04.24.04

NIAGfest Astronomy Convention and GreatCon

Camp Crosley, North Webster, Indiana. Cosponsored by the Northern Indiana Astronomical Group and the Great Lakes Region Astronomical League, this is the 18th annual gathering at Camp Crosley. For more information, contact NIAGfest Registration, 1308 Sunset Drive, Winona Lake, IN 46590; phone, 574.269.1856 (after 5 P.M.); e-mail, jtague@kconline.com; web site, clubs.kconline.com/was/niag.htm.

04.30.04–05.01.04

North Central Region of the Astronomical League Star Party and Convention

John H. Witte Observatory, Big Hollow Recreation Area, near Burlington, Iowa. The Southeastern Iowa Astronomy Club will celebrate its 20th anniversary during this annual gathering. For more information, e-mail dbphilabaum@mchsi.com; web site, www.seiac.com.

05.21.04–05.23.04

Georgia Sky View

Camp McIntosh, Indian Springs State Park, Georgia. Hosted by the Flint River Astronomy Club, this is the inaugural Georgia Sky View. This event will occur rain or shine. For more information, visit www.flintriverastronomy.org/GSV2004.htm.

05.28.04–05.30.04

Riverside Telescope Makers Convention

YMCA Camp Oakes, near Big Bear City, California. The theme for this year's gathering is "Transits and Occultations." Located in the San Bernardino mountains, the site offers dark skies at a high altitude. *Astronomy* associate editor Michael Bakich will be in attendance. For more information, visit www.rtmcastronomyexpo.org. ■

CONTACT INFORMATION

Please submit club announcements four months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Add your events to our on-line calendar at www.astronomy.com.

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RESOURCES

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BLACK HOLES IN THE MIDDLE

BOOKS — Black holes have long exerted a fascination as strong as their gravity, so every level of reader can find many books on the subject. Among those aimed at a popular audience is Kitty Ferguson's *Prisons of Light* (Cambridge University Press, New York, 1996). Also, take a look at *Black Holes, Wormholes, and Time Machines* by Jim al-Khalili (Institute of Physics Publications, Philadelphia, Pennsylvania, 1999). Besides clearly explaining the astrophysics behind black holes, Khalili delves into the way time behaves strangely in the vicinity of a black hole.

WEB — Because intermediate-mass black holes sit on the cutting edge of research, the material available on the web is skewed heavily toward professionals. An on-line series of fifteen *PowerPoint* frames describing the runaway growth of intermediate-mass black holes begins at *www.astro.washington.edu/stinson/IMBH/.*

COSMIC SNOWSTORM

BOOKS — To learn about the myriad small objects that lie in the outer solar system, read *Beyond Pluto* by John Davies (Cambridge University Press, New York, 2001). A more advanced work that incorporates ideas from many astronomers is *The Origins of Stars and Planets: The VLT View*, João Alves, ed. (Springer Verlag, New York, 2002). This book, the proceedings of a workshop held by the European Southern Observatory in 2001, presents both theoretical and observational results as well as suggestions for future observations.

WEB — The best source of information on the Internet about the Kuiper Belt and related subjects is *www.ifa.hawaii.edu/faculty/jewitt/kb.html.* This site is maintained by David Jewitt, co-discoverer of the first Kuiper Belt object: 1992 QB_1.

INTO THE ABYSS

BOOKS — *The Elusive Neutrino: A Subatomic Detective Story* by Nickolas Solomey (W. H. Freeman, New York, 1997) is a good but semi-technical introduction to neutrinos. This book both spans the history of particle physics and looks at what neutrinos can tell scientists about the structure and evolution of the universe.

ARTICLE — For a history of neutrino research, see "Ghostbusting the Universe" (*Astronomy*, December 2003), in which authors Alison Boyle and Ken Grimes describe the neutrino's place in the pantheon of particle physics and astronomy.

WEB — The best site for information about ANTARES comes from the project's page at *antares.in2p3.fr/*. The site also includes links to other major neutrino experiments like IceCube and the NESTOR project.

M67: THE ULTIMATE SURVIVOR

ARTICLE — For an excellent overview of our galaxy's longest-lived clusters, see "The Old Open Clusters of the Milky Way" by Eileen D. Friel (*Annual Review of Astronomy and Astrophysics*, vol. 33, 1995).

WEB — Open star clusters help scientists calibrate theories of stellar evolution because their stars share the same age, distance, and chemical composition but differ in mass. Learn more about our galaxy's open star clusters at *www.seds.org/messier/open.html.*

CANCER, LEO, AND LEO MINOR

BOOKS — For those who are just starting to get to know the constellations, Antonín Rükl's *Constellation Guidebook* (Sterling, New York, 1996) provides brief descriptions, colorful pictures, and illustrations of the constellations and the major deep-sky objects they contain. More advanced observers may want to pick up the older but more detailed *Observing the Constellations: An A–Z Guide for the Amateur Astronomer* by John Sanford (Simon & Schuster, New York, 1989).

If you're into astronomical history, Giuseppe Maria Sesti's *The Glorious Constellations*, trans. Karin H. Ford (Harry N. Abrams, New York, 1991) is a beautiful, 495-page tome that retells mythological stories from many cultures including Greek, Indian, Babylonian, and Chinese.

DISAPPEARING ACT

BOOKS — The only book published about grazing occultations is the out-of-print *Graze Observer's Handbook* by Harold Povenmire, 2nd ed. (JSB Enterprises, Indian Harbour Beach, Florida, 1979). Used copies still may be found at secondhand bookshops and through Internet booksellers such as *Amazon.com*.

WEB — IOTA's main web site is located at *www.lunar-occultations.com/iota*. A related page, maintained by occultation guru Rob Robinson, is at *www.lunar-occultations.com/rlo/rlondx.htm*. Doug Mink of the Harvard-Smithsonian Center for Astrophysics maintains the Stellar Occultations site at *tdc-www.harvard.edu/occultations/occultations.html.*

CAPTURING AURORAE

BOOKS — A beautifully illustrated book about aurorae is *Northern Lights: The Science, Myth, and Wonder of Aurora Borealis* by Calvin Hall, et al. (Sasquatch Books, Seattle, Washington, 2001). Another informative book with great photographs is *Aurora: The Northern Lights in Mythology, History, and Science* by Harald Falck-Ytter, trans. Robin Alexander (Anthroposophic Press, Hudson, New York, 1999). For an historical look at a pioneer in the field, read *The Northern Lights: The True Story of the Man Who Unlocked the Secrets of the Aurora Borealis* by Lucy Jago (Alfred A. Knopf, New York, 2001).

WEB — The first place to visit for information on auroral activity is the Solar Terrestrial Dispatch site at *www.spacew.com*. For other information, including forecasts of solar activity issued by the U.S. National Oceanic and Atmospheric Administration and a regularly updated picture gallery, check out *www.spaceweather.com.* ■

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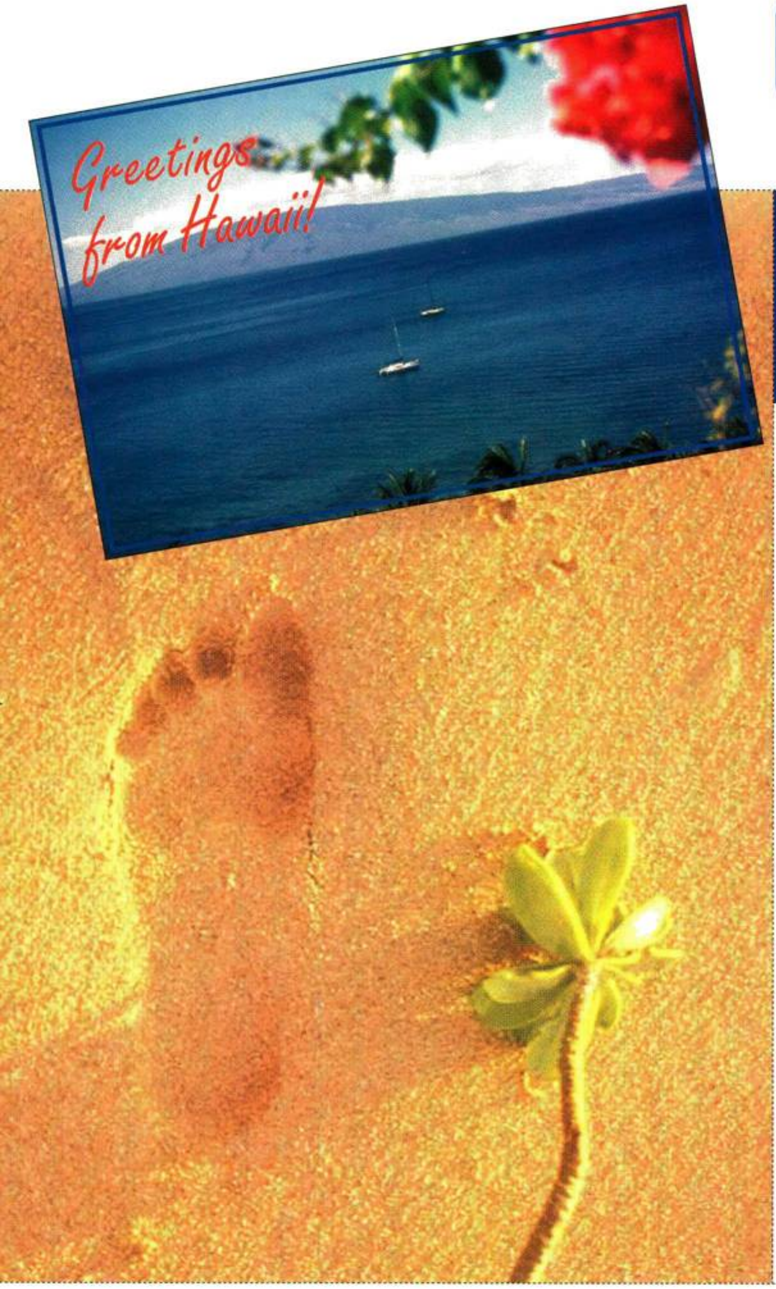

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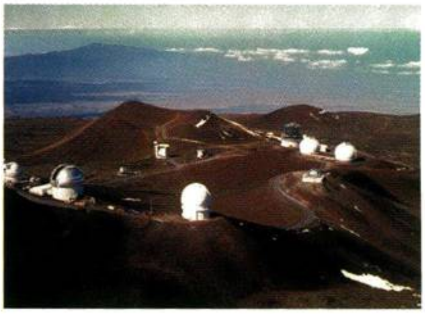

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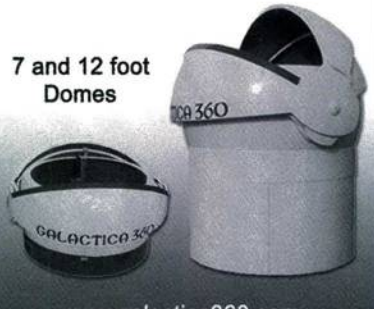

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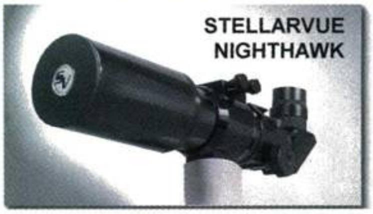

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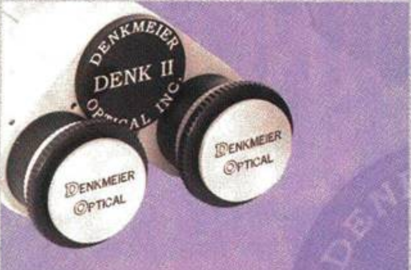

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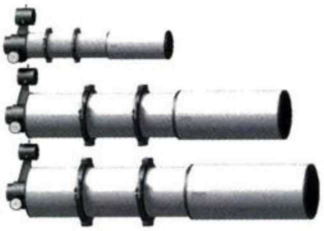

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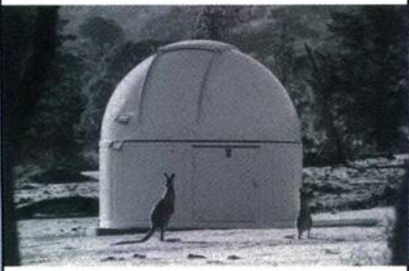

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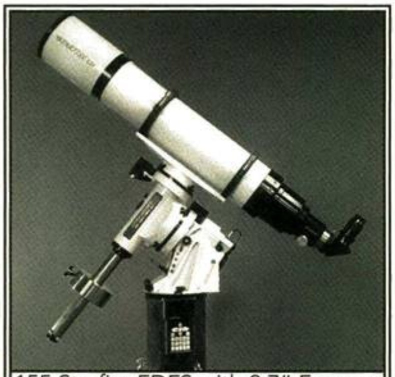

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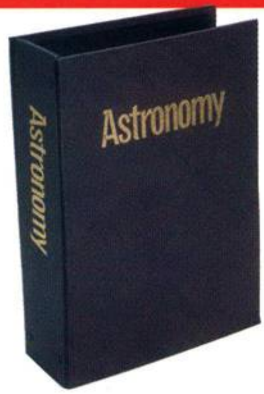

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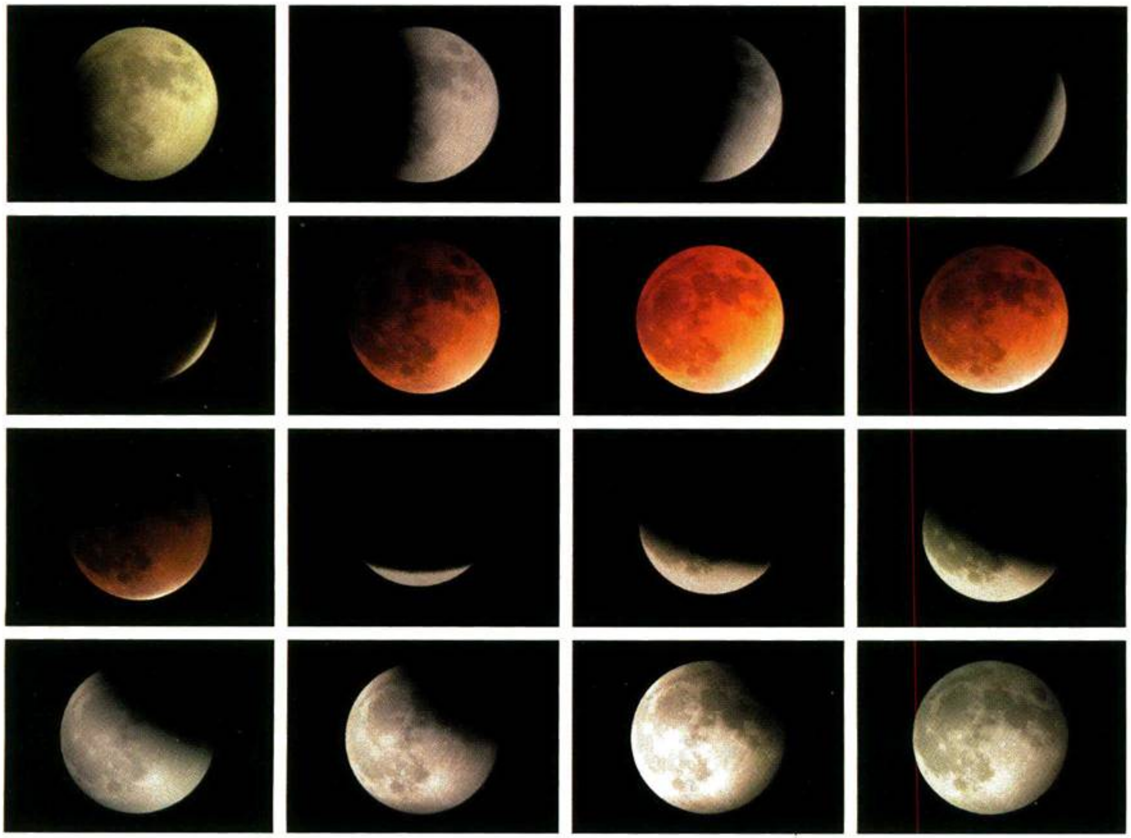


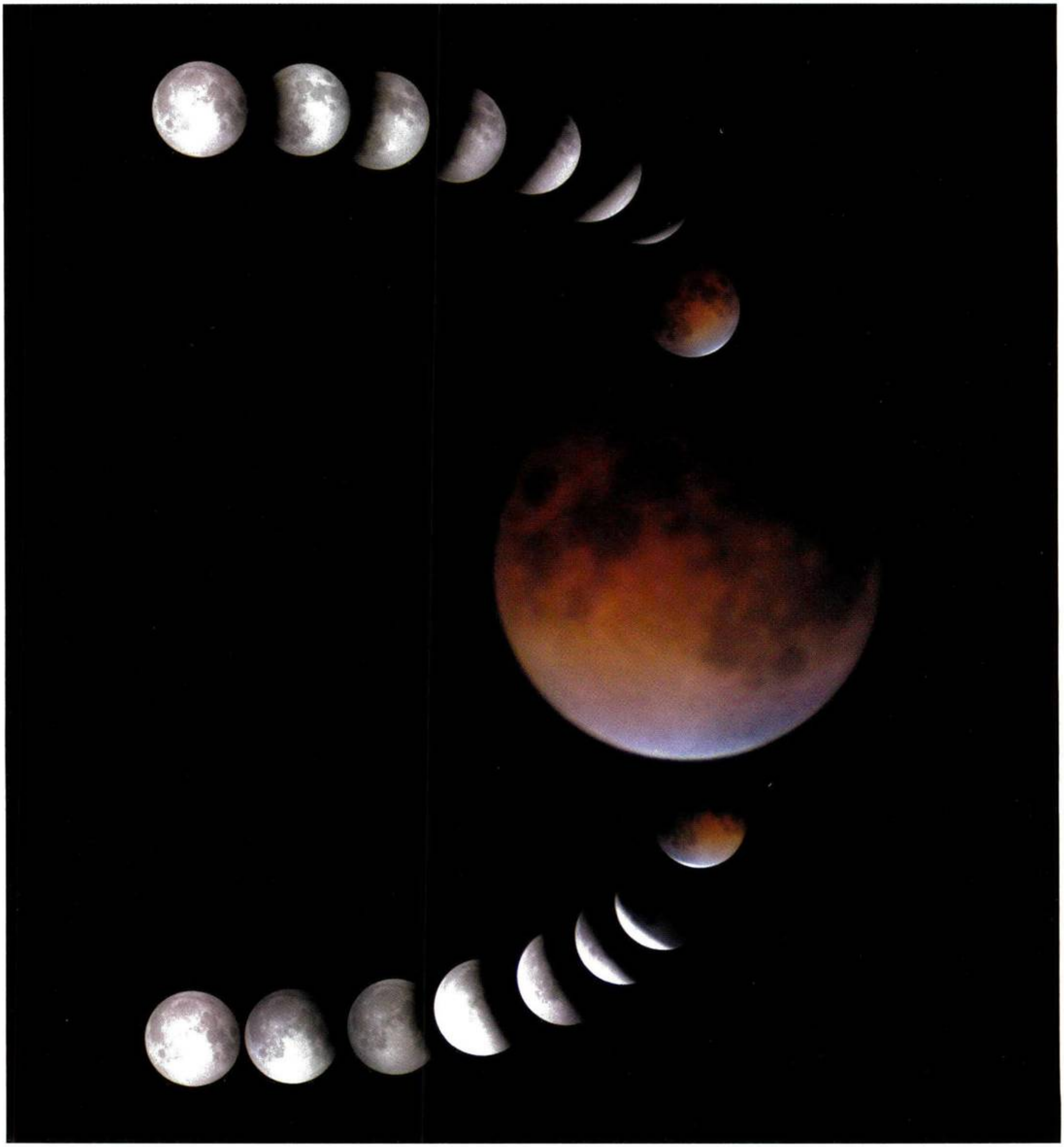
TOTAL LUNAR ECLIPSE COMPOSITE [All exposures were taken November 8, 2003, between 6:35 and 10:16 P.M. EST from North Kingstown, Rhode Island, using an 8-inch Meade LX90 Schmidt-Cassegrain telescope at f/6.3. Afocal exposures 1–4 and 13–16 were taken with a Sony Cybershot P7 digital camera set to ISO 100 and f/5.6 through a 40mm eyepiece attached to the telescope; exposures ranged from $\frac{1}{125}$ to $\frac{1}{800}$ second. Exposures 5–12 were taken with a Nikon F3 35mm camera attached to the telescope at prime focus and AGFA 200 color print film; exposures ranged from $\frac{1}{15}$ second to 4 seconds.] /// **MICHAEL MALONE**

A LUNAR ECLIPSE

Sublime celestial geometry

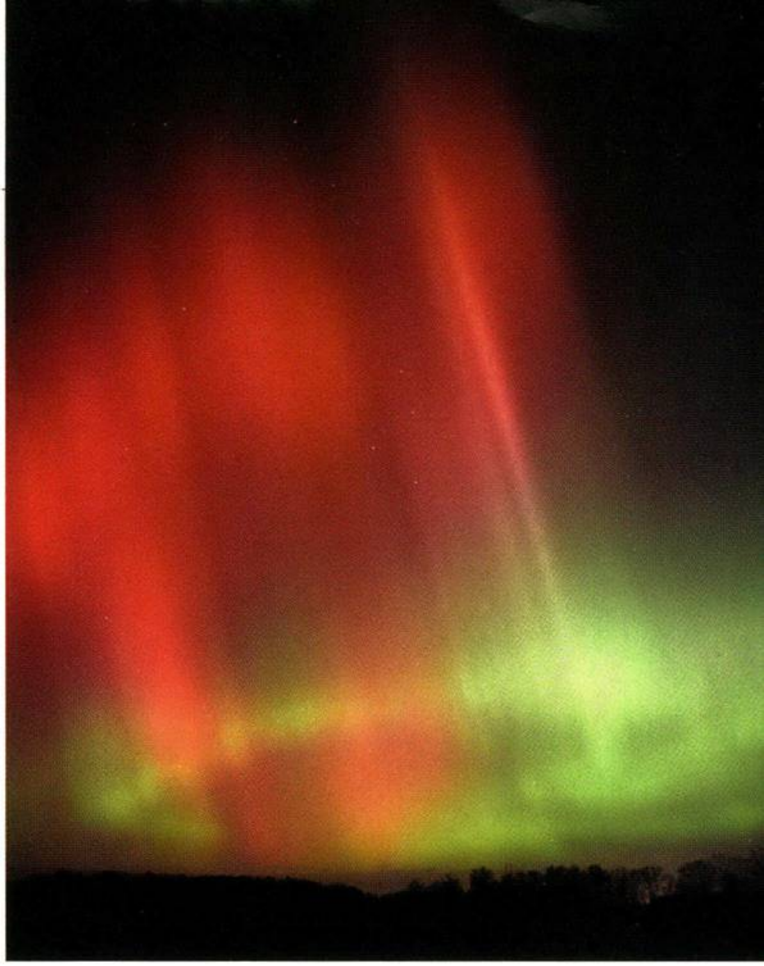
Today, observers note examples of sky geometry — the exact lineup of three bodies. On November 8, 2003, Earth cast a beautiful orange shadow on the Moon's face. A thousand years ago, people who worshipped Norse gods like Odin and Thor believed the Sun (Sol) and the Moon (Mani) were living creatures chased in their appointed rounds by two enormous wolves. It was foretold that both wolves would overtake and devour their celestial prey at Ragnarok — the end of the world. During an eclipse, when the shadow of a wolf was seen on the face of either Sol or Mani, people would bang drums or kettles and scream in order to scare the wolf off. Groups of people still gather during eclipses but not to ward off a mythological creature.

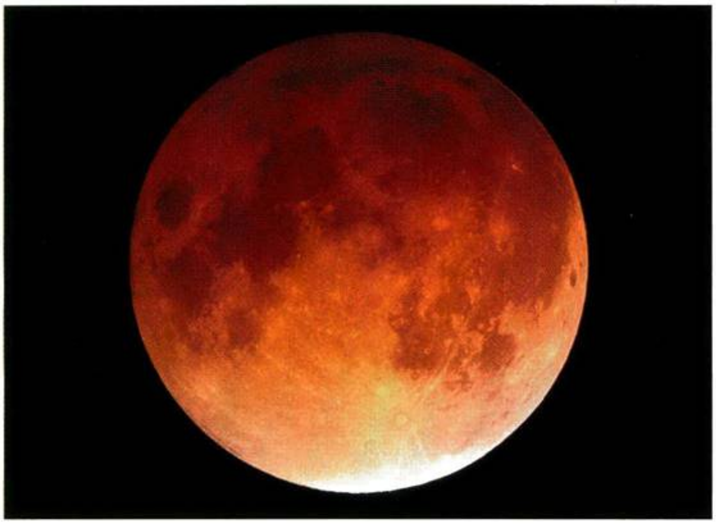
Send your photos to: ASTRONOMY reader gallery, P.O. Box 1612, Waukesha, WI 53187; e-mail to readergallery@astronomy.com. Please include your full name, date and location of image, and complete photo data: telescope, camera, film, and exposure information.

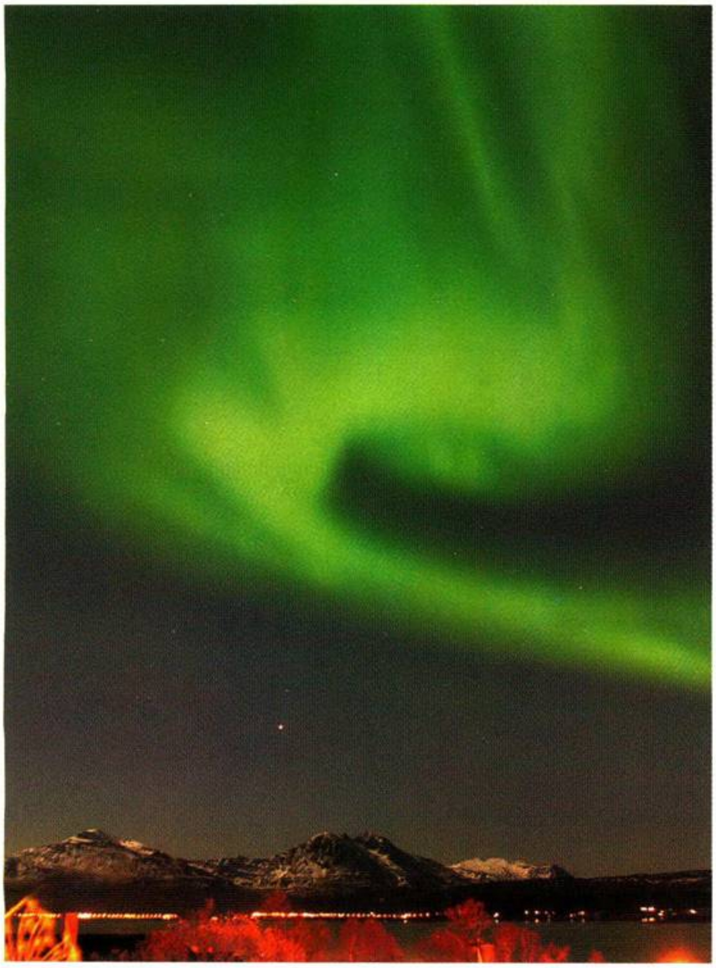


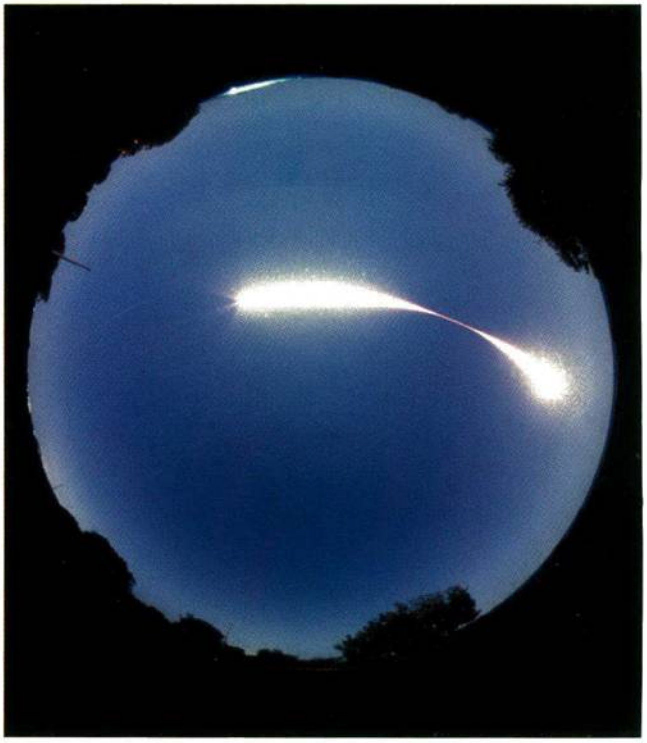
LUNAR ECLIPSE MOSAIC [4-inch Vista 1010 refractor at f/10, Canon G3 digital camera set equivalent to ISO 400, eyepiece projection, exposures from 1/200 second at Full Moon to 1 second at totality at approximately 10-minute intervals, taken November 8, 2003, between 6:40 and 10:15 P.M. EST from Ottawa, Ontario, Canada] /// **MIKE FERRIS**

Right. **AMAZING AURORAL COLORS** [Nikon F2 35mm camera with Tamron 17mm f/3.5 lens, Fuji NPZ 800 film, 25-second exposure, taken October 29, 2003, at 9h06m UT from LaOtto, Indiana] /// **ROBERT B. SLOBINS/PHOTOTAKE**







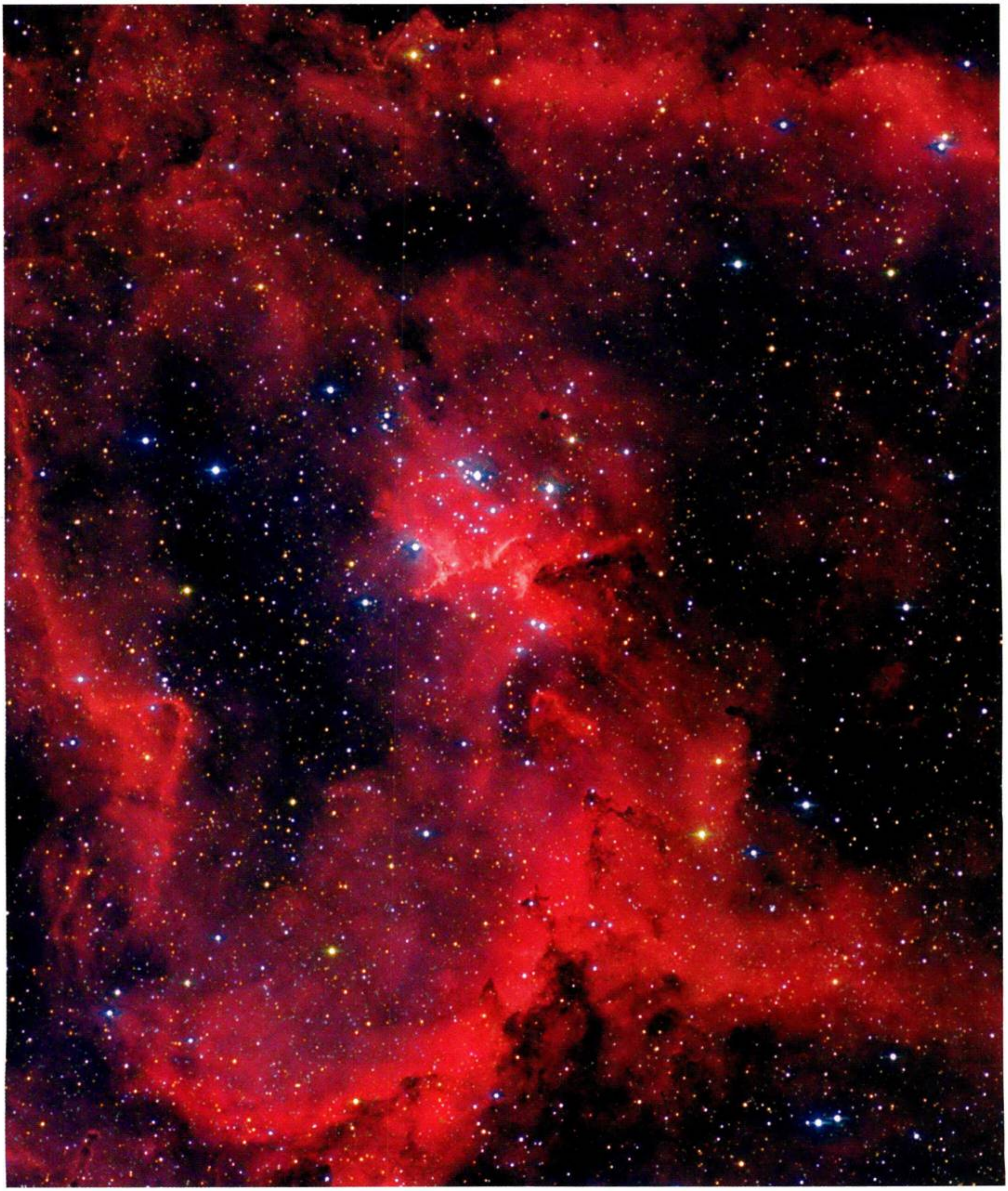


Top left. **LUNAR TOTALITY** [5-inch Meade ETX125 Maksutov-Cassegrain telescope at f/15, Canon G2 digital camera, 2½-second exposure at ISO 100, taken November 8, 2003, at 8:25 P.M. EST from Charlottesville, Virginia] /// **RICHARD SIMON**

Bottom left. **MARS SWIMS IN AURORAL LIGHT** [Canon 10D digital camera, 17–35mm zoom lens at f/2.8, 6-second unguided exposure, taken November 9, 2003, at 20h37m UT from Tromso, Norway] /// **HINRICH BAESEMANN**

Above. **LUNAR ECLIPSE TRAIL** [Sigma 8mm fish-eye lens at f/32, Kodak Ektachrome 200 film, 6-hour and 30-minute exposure, begun at 9h15m UT on November 8, 2003, from Ragusa, Sicily] /// **GIANNI TUMINO AND MELANIA PLUCHINOTTA**

OPEN CLUSTER IC 1805 IN CASSIOPEIA (4-inch Takahashi FSQ-106 refractor at f/5.3, SBIG ST-10XME CCD camera, hydrogen-alpha–RGB image with exposures of 210, 20, 20, and 32 minutes, respectively, imaged September 28, 2003, from Oceanside, California) /// **DANIEL B. PHILLIPS**



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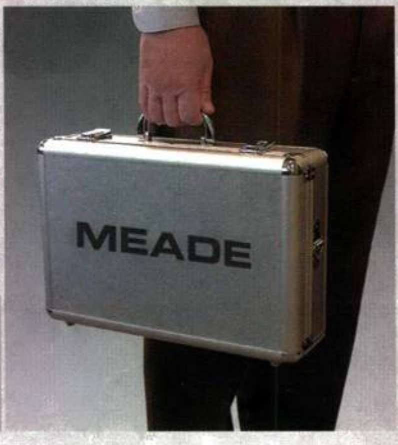

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